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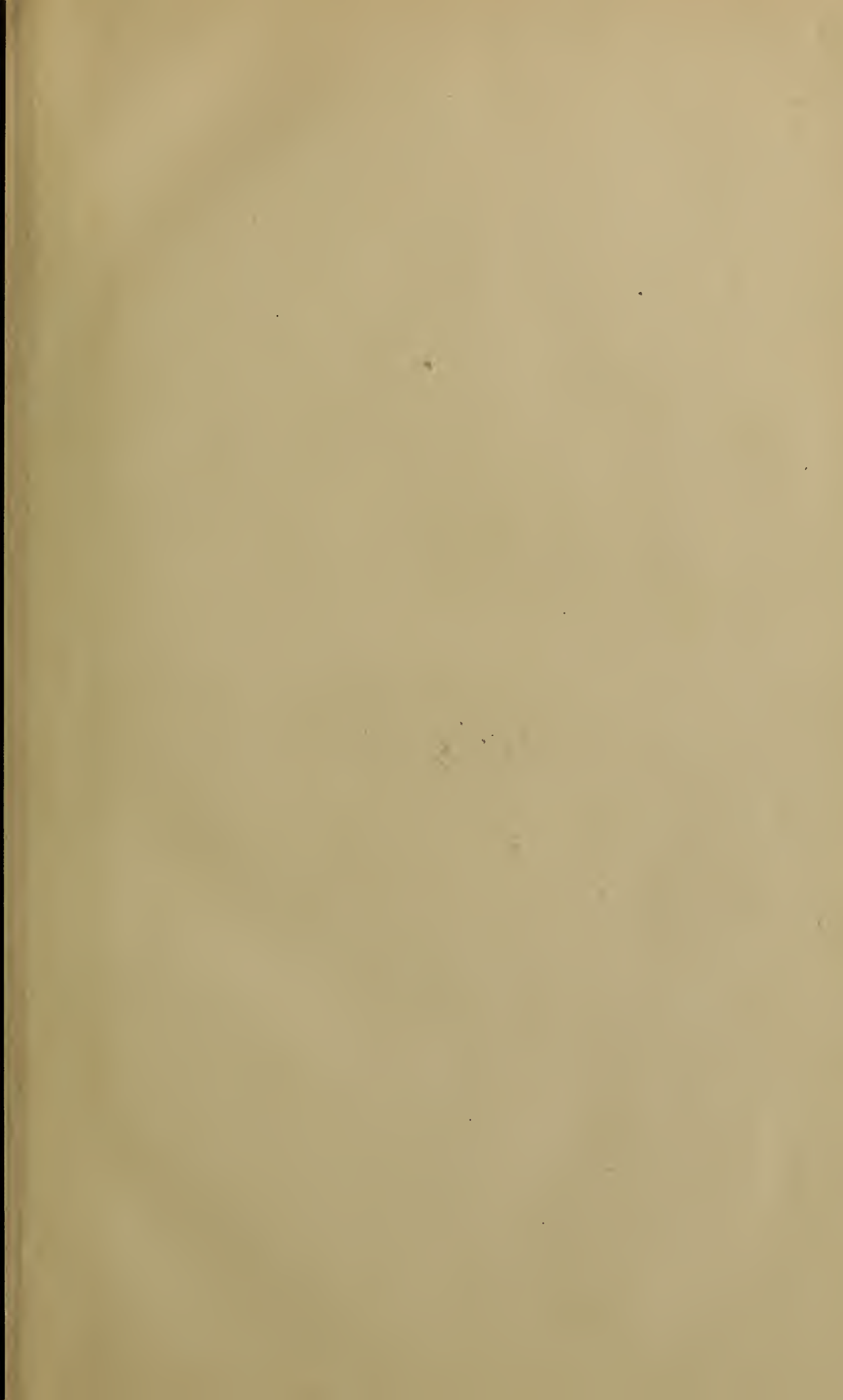
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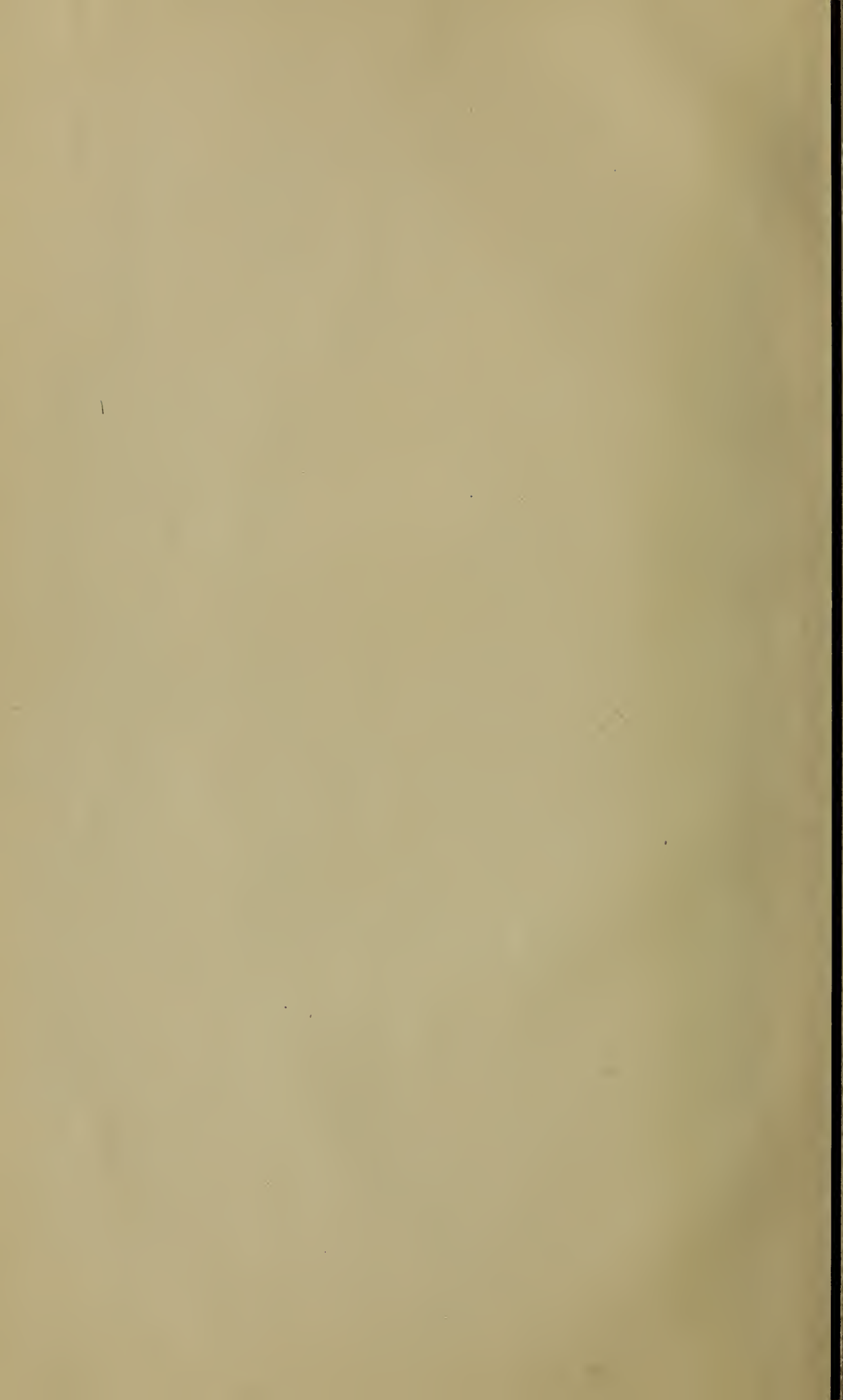


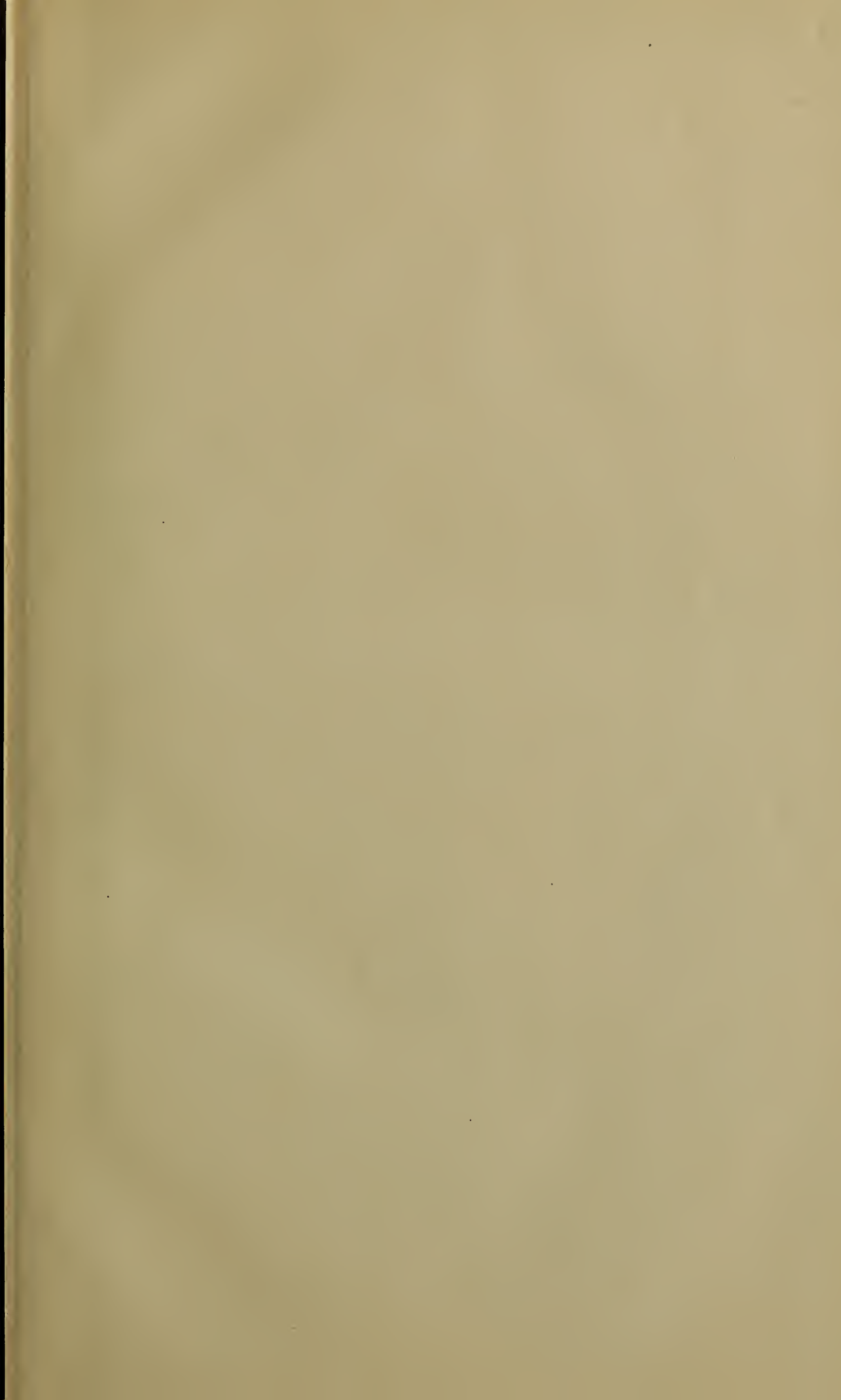
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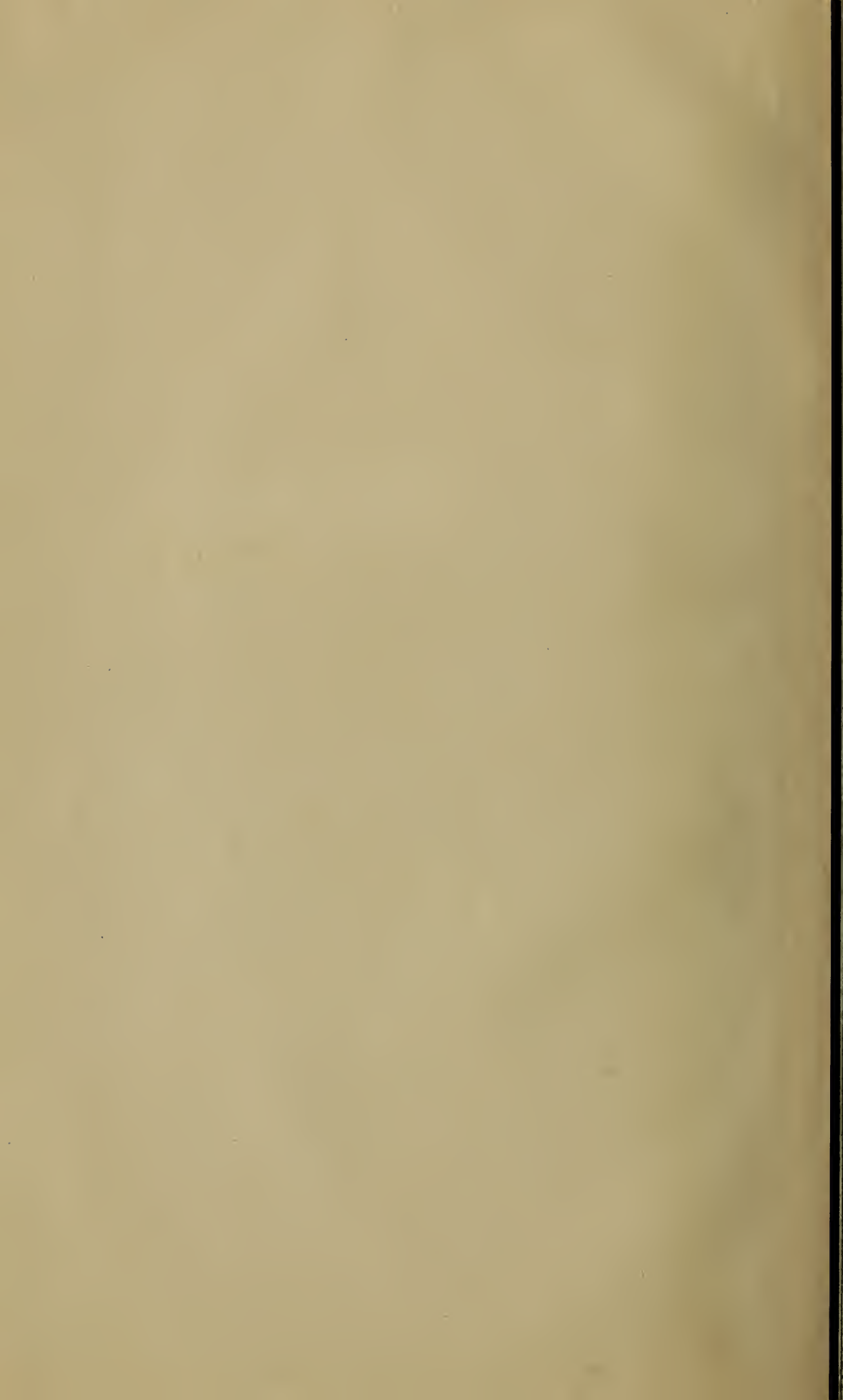
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DEPARTMENT OF COMMERCE AND LABOR

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

A. H. BALDWIN, Chief

SPECIAL AGENTS SERIES—No. 65

CHEMICAL INDUSTRIES

OF BELGIUM, NETHERLANDS,
NORWAY, AND SWEDEN

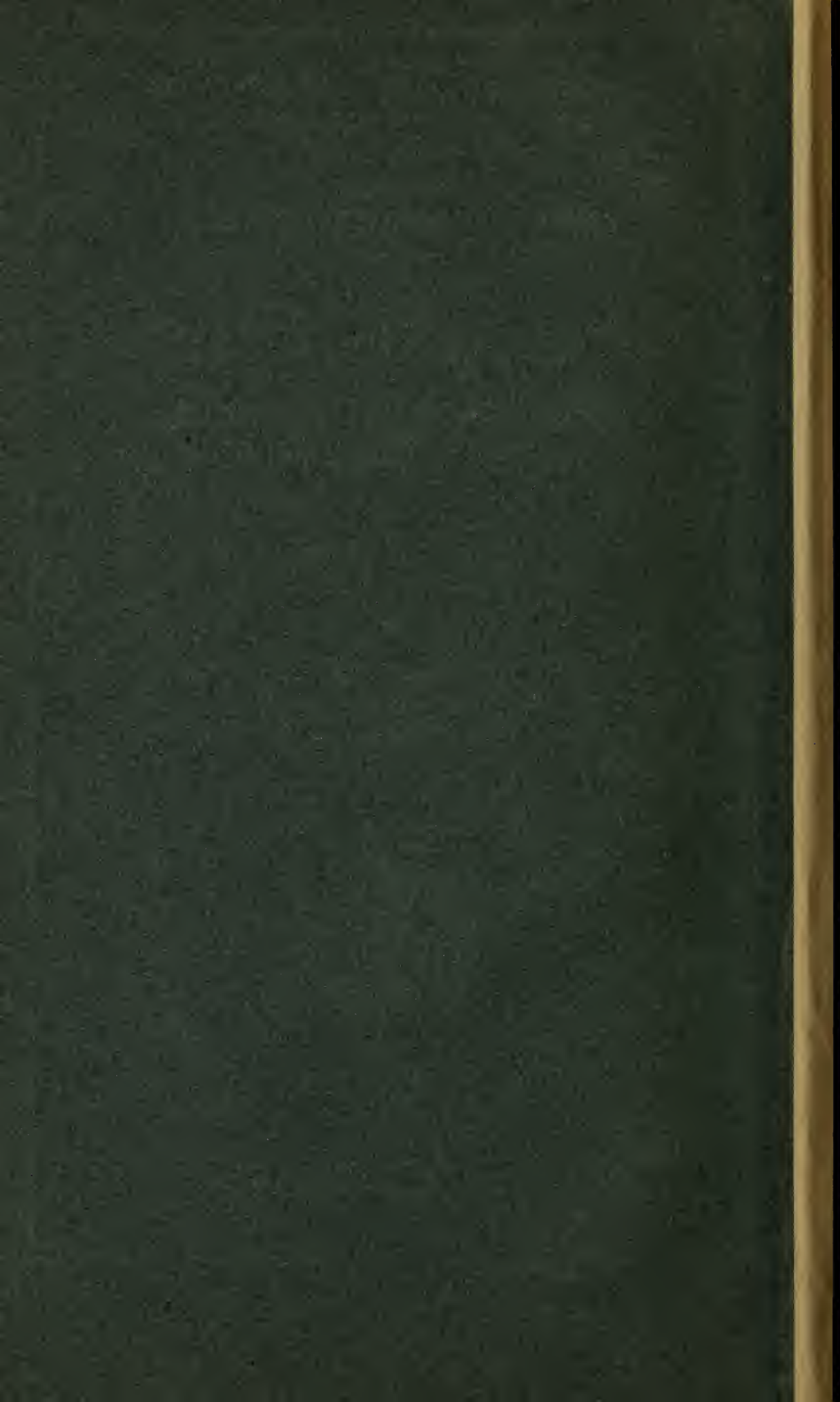
By

THOMAS H. NORTON

Consul at Chemnitz, Germany, on detail as
Commercial Agent of the Department
of Commerce and Labor



WASHINGTON
GOVERNMENT PRINTING OFFICE
1912



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U. S. DEPARTMENT OF COMMERCE AND LABOR
BUREAU OF FOREIGN AND DOMESTIC COMMERCE
A. H. BALDWIN, Chief

SPECIAL AGENTS SERIES—No. 65

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LETTER OF SUBMITTAL.

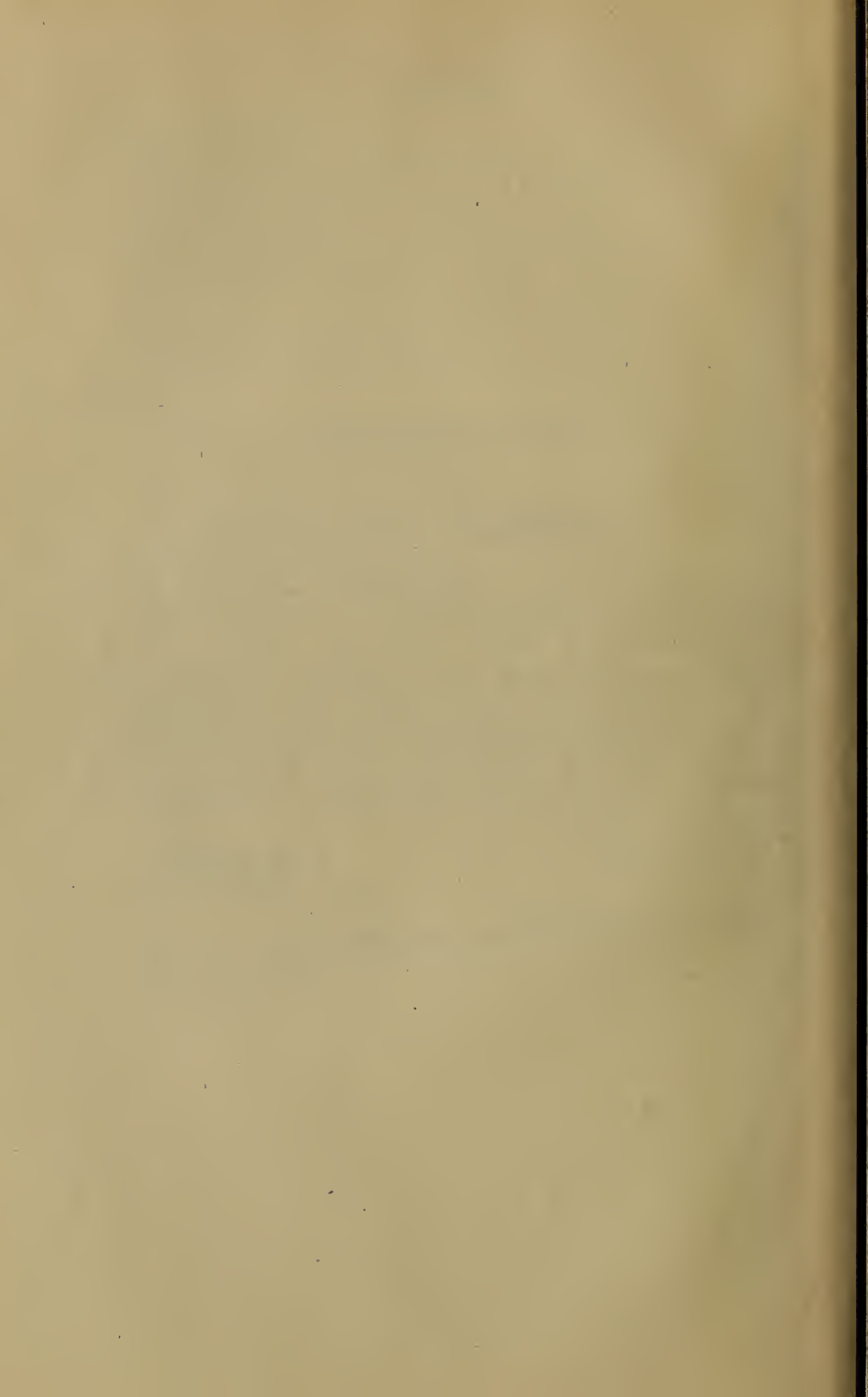
DEPARTMENT OF COMMERCE AND LABOR,
BUREAU OF FOREIGN AND DOMESTIC COMMERCE,
Washington, November 22, 1912.

SIR: I have the honor to submit herewith a monograph on the chemical industries of Belgium, Netherlands, Norway, and Sweden by Consul Thomas H. Norton, of Chemnitz, Germany, who was detailed as commercial agent of the Department of Commerce and Labor. The report deals with the supply of raw materials used in the chemical industries, the methods of manufacture, the cost of production, and the foreign and domestic trade of each of the countries mentioned. There are included observations on the state of the chemical-goods trade with the United States and the prospects of improving this trade.

Respectfully,

A. H. BALDWIN,
Chief of Bureau.

To Hon. CHARLES NAGEL,
Secretary of Commerce and Labor.



CHEMICAL INDUSTRIES OF BELGIUM, NETHERLANDS, NORWAY, AND SWEDEN.

BELGIUM.

INTRODUCTION.

Although the Kingdom of Belgium occupies a small area, its industrial activity places it relatively in the foremost rank among manufacturing countries. This position dates, in fact, far back in the history of the land long before the establishment of the present political organization.

The development of the chemical industries of Belgium has kept fairly even pace with the evolution of the textile, metallurgical, and other interests. While not so diversified as in Germany, they still constitute an important source of national wealth and form the basis for a large and profitable international movement.

The leading chemical industries have grown naturally as a result of the impulse to utilize most effectively the mineral and agricultural wealth of the land. The abundant deposits of coal underlying one-twentieth of the Kingdom have exerted a powerful influence in this direction, facilitating the organization of those branches requiring a large expenditure of fuel, as well as those aiming to use the by-products of coking, etc. The presence of ores so important as those of iron and zinc had likewise much to do in favoring the establishment of special industries. Another factor has been the exceptionally high standard of Belgian agriculture, which has acted as a powerful stimulus upon all interests connected with the fertilizer trade. Finally, the excellent maritime location of the country has been notably favorable.

As examples of the industrial growth of late years, the following figures show the increase in the value of the output from 1880 to 1908 for a few branches: Coal mined, 123 per cent; quarry products, 60 per cent; zinc, 210 per cent; glass, 90 per cent; sugar, 288 per cent. This upward tendency is reflected in a number of minor industries.

Belgium feels to some extent the competition of its two neighbors, France and Germany. As a result, the technical chemists of the Kingdom have made less effort to produce synthetic compounds of complex nature and great cost. Their endeavors have been concentrated rather in building up the industries producing staple articles of low value. In this line they have shown a high degree of inventive skill, capacity for organization, and commercial acuteness; so much so, in fact, that Belgium chemicals frequently come into sharp competition with those of French and German origin, and not infrequently invade the domestic markets of the adjacent countries.

SULPHURIC ACID.

There are 57 factories in Belgium engaged in the manufacture of sulphuric acid or employing it as an important raw material. The chief products in the latter are other minerals, various sulphates, and especially superphosphates. They possess a total motive power of over 6,000 horsepower and employ about 5,000 workmen. Two employ over 400 workmen, and only one uses more than 500 horsepower. The average wage is 60 cents per day, a rate materially below that prevailing in Germany. The maximum wage for skilled labor rarely exceeds \$1 per day. As a rule works are so located that raw material can be furnished by water. Some are placed alongside zinc works, to which they supply roasted ore; others adjoin the great glass works, which depend upon them for sodium sulphate. A number of establishments are so located that they can easily secure coal from the German mines, which costs 20 to 40 cents less than the Belgian coal.

Of the above-mentioned category of chemical works, 26 factories are direct producers of sulphuric acid. In 16 of these the production of superphosphate is a prominent feature. The total volume of lead chambers in use is about 400,000 cubic meters. The annual production of acid is much less than the theoretical capacity of the works. It varies from 300,000 to 320,000 tons of acid, averaging 60° Baumé.

The raw materials used as sources of sulphur are zinc blende and iron pyrites. The latter is imported chiefly from Spain and Portugal and occasionally from Japan. Belgium itself produces only about 200 tons of this mineral annually. The copper pyrites of Portugal and also that of Norway is not infrequently employed in Belgian works, the 2 to 3.5 per cent of copper being extracted by cementation.

Besides the domestic production of zinc blende, which averages annually a little over 1,000 tons, there is a large import, especially from Algeria, France, Germany, Sardinia, and Sweden, and even from Australia and Japan. The imports from America have ceased completely during the past few years. The Algerian ore, totally free from arsenic, is employed in producing the purest grades of acid. Much of the zinc ore is treated in acid factories connected with zinc works. The charge for roasting zinc blende is usually \$1.55 per ton and all cost of transport.

METHODS OF ROASTING PYRITES AND ZINC BLENDE.

The Maletra pyrites kiln is used in nearly all the works. One establishment has introduced German Humboldt mechanical kilns, but recognition of this type is slow, as the cost of manual labor in Belgium is relatively low.

In roasting zinc blende the Eichhorn muffle oven, with slight modifications, is in general use. Each oven is divided into four independent, symmetrical divisions, differing in this respect from the Rhenania type, common in Germany, which has but two divisions. Provision is made for heating the air entering the lower part of the muffle by conducting it through passages in the inclosing masonry. A temperature of 900° to 1,000° C. is maintained in the muffle. The gas issuing from the muffle contains 6 to 7 per cent of SO_2 , and much of this is already oxidized to SO_3 , from 4 to 30 per cent of the sulphur present being in the form of trioxide. With the average

blende, containing 25 per cent of sulphur, there is a yield of roasted ore equal to 87 per cent of the original weight. With careful management this is obtained free from sulphur, an essential feature when it is to undergo reduction to metallic zinc.

In a few Belgian works, where there are frequent changes in the use of blende or pyrites, the Delplace combination oven has been introduced. This consists of a series of superimposed shelves, much as in the ordinary pyrites kiln, but so constructed that with the aid of a hearth the entire system can be transformed into a muffle furnace. In the Delplace oven the consumption of fuel amounts to 11 per cent of the weight of blende employed. In the Eichhorn type it is usually 15 per cent.

Various experiments have been made in Belgium with mechanical roasters for zinc blende, but thus far without success. In some works the waste heat from the roasting ovens is utilized to partly coke the coal employed. The resultant gas and coke are both burned beneath the muffles.

Workmen in charge of pyrites kilns and blende furnaces are often paid according to the amount of ore roasted, with a certain system of premiums for high yields. The method is less in vogue where zinc blende exclusively is roasted.

The purple ore withdrawn from the pyrites kilns is sold to some extent to Belgian blast furnaces; the bulk, however, is exported to German works. Purple ore commands from \$1.55 to \$1.75 per ton. The residues from the burning of copper pyrites are always submitted to the cementation process, even when the percentage of copper falls as low as 0.3 per cent.

BELGIAN CHAMBER SYSTEMS.

In the Belgian chamber systems the average unit contains 200,000 cubic feet. The largest unit in operation has 282,000 cubic feet. The value of the newly devised Moritz chambers has been promptly recognized in Belgium, where 3 of the 8 sulphuric-acid works equipped with this valuable feature are located. They are the Société Anonyme des Superphosphates et Guanos, at Ghent (140,000 cubic feet); the Société Anonyme des Industries Chimiques de Wisèle (265,000 cubic feet); and the Rosier Compagnie, at Moustier (282,000 cubic feet). All of these establishments report a very marked economic advantage in the use of the Moritz chambers, and Belgian works enlarging their capacity will adopt this new system, according to the present opinion of technical chemists. There is a general recognition that this method of construction involves less space, means less depreciation and longer life for the chambers, and effects a notable saving in the consumption of nitric acid.

Two Belgian works have adopted the circular construction—a central chamber inclosed by an annular chamber. The Glover and Gay-Lussac towers are located in the space between the two. The device has failed to demonstrate any advantage over the ordinary rectangular system.

Forced draft is now of general application. In the works of the Vieille Montagne—the largest in Belgium—there are 10 units. Each unit is provided with a ventilator that withdraws the gas from its Gay-Lussac tower and forces it into a single large central Gay-Lussac. From the latter the combined gas current passes through

a tower fed with water. As a result nitric vapors are almost completely absorbed. There is an extended use in Belgian works of the Delplace automatic meter for controlling the volume of acid distributed to the Glover and Gay-Lussac towers. The introduction into the lead chambers of water in the form of spray in the place of steam is becoming general, especially for the warmer season of the year.

CONCENTRATION METHODS.

For the concentration of sulphuric acid the Delplace retorts of platinum were in general use a decade ago. They have now disappeared almost completely since the enormous increase in the value of platinum. In a few factories use is made of the Hartmann & Benker system of evaporation in a series of porcelain basins. These are usually arranged in rows of 20 basins, each slightly higher than the next succeeding. Two such rows are located side by side over a sloping furnace. Chamber acid is concentrated to 56° Baumé in open lead pans provided with heating coils. The 56° acid enters the topmost basin of a series and passes downward from one basin to another by means of projecting lips, until in the last of the series it attains 66° Baumé.

This method is specially adapted for the concentration of pure acids, as there is no contamination from the products of combustion in the furnace. These porcelain basins replace the more fragile glass basins of earlier days, but are themselves liable to crack occasionally as the result of changes in temperature, and do not resist absolutely the attack of boiling sulphuric acid. They are now being replaced with success by basins of fused quartz. These latter are absolutely unaffected by alterations of temperature. For the purpose in question basins are made with a diameter of 12.2 inches and a depth of 5.1 inches. The cost of such a basin is \$5.95. Good results have also been secured by the use of basins made of so-called neutral iron. This combination of iron and silicon is almost totally unaffected by boiling sulphuric acid. Its chief disadvantage lies in the difficulty of working the material.

KESSLER EVAPORATOR—GAILLARD TOWER.

Where purity is not so essential, the Kessler apparatus is largely used. This consists essentially of a shallow vat of sandstone inclosed in lead, in which 57° acid is introduced. The hot gases from a coke furnace play over the surface of the acid and produce a rapid evaporation. A series of partitions above the surface cause the gas current to pass back and forth several times before leaving the vat. The latter is surmounted by a so-called regenerator, containing perforated plates of lava, over which the weak acid trickles on its way to the evaporation vat, so that concentration begins at this stage, and the heat is well utilized. The operation is continuous, acid of 66° issuing from an outlet at one end of the vat. The gas current on leaving the regenerator passes through a tower lined with lead and filled with fragments of coke. This acts as a filter to retain particles of acid carried along mechanically. The weak acid collected in the filter ranges in strength from 15° to 30° Baumé. It is directed to the Glover tower, or is employed in extracting the residues of copper pyrites.

During the past five years the Kessler evaporator has frequently been replaced by the Gaillard tower, which is regarded now in Belgium as the simplest and most effective device for concentration on a large scale. The tower is constructed of Volvicq lava, cut in the form of rings, which are cemented one upon another with the aid of a mixture of ground lava and water glass. The usual height is 50 feet and the diameter 7 feet. Chamber acid is forced into the tower at the top in the form of spray. In descending it encounters a current of hot gas coming from a coke furnace and entering the tower slightly above its base. Under these conditions concentration takes place easily and completely. Acid of 66° collects on the bottom and is drawn off through cooled pipes. The gas current, saturated with aqueous vapor, issues from an opening in the top of the tower, passes through a smaller tower filled with refractory brick, over which water trickles, and finally through a coke filter similar to that of the Kessler apparatus.

The contact method of manufacturing sulphuric acid is still in its infancy in Belgium. Two factories have the requisite equipment, but little attempt is made at production on a large scale. As a matter of fact there is only a small demand in the industries of the Kingdom for sulphuric anhydride. The necessity of using very pure sulphur dioxide, free especially from arsenic, has militated strongly against the attempts to establish the process upon an extensive technical basis.

TRANSPORTATION—TRADE.

The transportation of sulphuric acid in Belgium, apart from the use of the carboy, is usually effected in iron reservoir cars holding 10 to 15 tons. Some use is made of cars fitted with containers of sandstone, eight to the car. Barges with four to six cylindrical iron reservoirs, each holding 25 tons, are employed for shipment by water. Iron cylinders holding 100 to 300 liters (liter=1.056 quarts) are employed usually when the acid is shipped to foreign countries. When shipment is made in iron containers the acid is over 50° Baumé.

The export of sulphuric acid is chiefly to Germany, the total for 1911 being 89,000 tons; Belgium is, in fact, the only country shipping large amounts of sulphuric acid to Germany. As freights are not high, the competition frequently causes very low rates for acid along the Rhine and in Westphalia. Of the total production about two-thirds is required in the manufacture of superphosphate. The other domestic industries consuming important amounts are the manufacture of hydrochloric acid, sodium sulphate, nitric acid, the various metallic sulphates, glucose, nitroglycerin, the saponification of fats, and the refining of rapeseed oil.

NITRIC ACID—HYDROCHLORIC ACID AND SODIUM SULPHATE.

There are 13 factories engaged in the manufacture of nitric acid. In most cases the bulk of the product is used in the factory itself in connection with other operations. The Valentiner method of distilling under a partial vacuum, with air dilution, is mostly used, although condensation by the Sgoklund and the Guttman-Rohrmann systems is also encountered. Belgian factories are dependent upon German, and especially upon English, manufactures of acid-proof, air-tight apparatus of stoneware for the needs of this branch.

Most of the nitric acid produced is of 36° strength. A certain amount of 45° and of 48° is prepared for use in the manufacture of artificial silk and high explosives. The annual production, calculated to acid of 36°, is over 11,000 tons. There is an export of about 2,000 tons to the adjacent countries, chiefly to France and the Netherlands. A large fraction of the production is utilized in the domestic manufacture of sulphuric acid.

There are 11 factories that produce annually about 30,000 tons of sulphate and nearly as much hydrochloric acid. Rock salt, brought from Germany, is the usual raw material. Most of the sulphate is consumed in the great glass works of Belgium. The domestic supply is now insufficient to meet the increasing demands of the glass industry, and there is an annual import of sulphate exceeding 50,000 tons. It is furnished chiefly by Germany, but France and Great Britain also contribute. The acid is employed in the cementation of copper and in the manufacture of zinc chloride and acetic acid. In the chemical works at Droogenbosch the acid vapors given off from the sulphate oven are used directly for the production of chlorine by the Deacon process. The acid is shipped in bulk on cars provided with reservoirs of iron, lined with ebonite, which have taken the place of the wooden vats coated with tar formerly in vogue. There is a very limited export of either sulphate or acid.

The production of these two chemicals, as well as the manufacture of sulphuric acid in Belgium, is controlled by the well-organized syndicate, the Union Commerciale, which rigidly restricts production, dividing it equitably among the various works; it thus prevents overproduction and keeps up prices. This syndicate was founded in 1890 and has prevented any serious crises in the sulphuric-acid industries.

SUPERPHOSPHATE.

The manufacture of superphosphate has been highly developed in Belgium, partly on account of the abundant supply of cheap sulphuric acid, partly in response to the exceptionally large demands for fertilizers brought about by the intensive agricultural methods of the land. There are 33 superphosphate factories—of these, 16 manufacture their own acid. The industry centers largely about Antwerp on account of the ease with which raw material can be procured and shipments to other countries effected.

Belgium has fairly extensive deposits of phosphate rock, but they are mostly of an inferior grade. The rock found around Liege and Mons contains 50 per cent or less of tricalcium phosphate. Richer deposits, averaging 60 per cent, are encountered in the vicinity of Baudour. As it is impossible to secure with the domestic rock superphosphate containing much over 15 per cent of P_2O_5 , the practice is to mix Belgian phosphates with the purer and richer material imported from other countries. Some is imported from the region of the Somme in France. Larger amounts come from Algiers and Tunis and also from the islands of the Pacific. About 65,000 tons of Florida phosphate are imported annually. There is also a small import from the island of Arruba, in the West Indies. These foreign phosphates cost \$9.60 to \$11.60 per ton, while the native rock ranges from \$4.80 to \$5.80.

In the treatment of rock, chamber acid of 53° Baumé is used chiefly. In some works the sulphuric acid employed in purifying coal tar finds here a final utilization.

EQUIPMENT OF FACTORIES.

The general equipment of the factories and the process do not vary much from what is encountered in the best German establishments. The American Griffin crusher for phosphate rock is widely employed. The mixers are mostly of the vertical type, and ordinarily 9 feet 10 inches in diameter and 3 feet 3 inches high. A mixer is usually so located that it can be emptied at will into two adjoining cellars. In a few factories portable mixers running on rails have been introduced. Cellars are almost invariably provided with powerful ventilators for the complete removal of the fumes of hydrofluoric acid and silicon fluoride. Both are transformed into sodium fluosilicate. Drying apparatus is still used to some extent, especially when low-grade phosphate has been employed. As a rule the hot superphosphate, after removal from the cellars, is mixed with 5 per cent of its weight of degelatinized bone meal and finely ground Algiers phosphate. This treatment lowers the amount of free acid present and yields at the same time a sufficiently dry product. The larger factories are arranged to avoid all unnecessary expenditure of power in handling the great masses of material. The crushers are stationed on the ground floor. The phosphate after being powdered passes to an upper floor, where the mixers are located. Immediately below these are the cellars, and there is a continual descent at each successive stage of the handling. Automatic lines of cars and aerial transport by cable, with the aid of electricity, are introduced in several establishments. Workmen in the superphosphate factories are paid usually by the amount of material handled and not by the day.

STATISTICS OF THE INDUSTRY.

The output has increased rapidly during recent years. In 1903 it was 230,000 tons; in 1910 it had reached 540,000 tons, or 6 per cent of the world's production. This increase has been largely due to the marvelous expansion of the export trade. In 1910 this had reached 346,080 tons against an import of 69,840 tons (almost entirely from France). The average value per metric ton of this export was \$9.86. The net export of superphosphate from Belgium, 276,240 tons, compares favorably with the net export of Germany—150,400 tons—in 1911. The total export of artificial fertilizers from the United States in 1910 was 39,500 long tons.

The dominant position occupied by Belgium in supplying foreign demands for superphosphate renders it a matter of interest to analyze its export trade. In 1910 the shipments were as follows:

To—	Metric tons.	To—	Metric tons.	To—	Metric tons.
France.....	119,900	United States.....	4,100	India.....	950
Spain.....	60,000	Switzerland.....	2,700	Australia.....	600
Germany.....	57,000	Dutch colonies.....	2,500	Natal.....	500
Netherlands.....	54,900	Sweden.....	2,200	Mexico.....	200
Great Britain.....	19,900	Egypt.....	1,600	Cape Colony.....	100
Portugal.....	19,500	Russia.....	1,200	Brazil.....	40
Italy.....	4,600	Austria-Hungary.....	1,000		

In addition to the production of normal superphosphate there is an annual production in a single factory of about 500 tons of bone superphosphate made from degelatinized bones. The entire output is exported to France. In another factory spent animal charcoal from the sugar works is converted into superphosphate. The annual production of 400 tons is used locally.

GUANO AND THOMAS MEAL.

The treatment of raw guano with sulphuric acid is carried on extensively at Burght, where a large factory is devoted to the production of soluble guano. The imports of crude guano in 1910 were 15,300 tons from Peru and 3,000 tons from the west coast of Africa. Much of the soluble guano is exported to Germany and the Netherlands. A single factory is devoted to the manufacture of artificial guano. The raw material used is leather waste and the refuse from fish-preserving works.

Belgium was one of the first countries to recognize the fertilizing value of Thomas slag. The manufacture of ground slag has assumed large proportions, and Belgium has become a leading exporter of this important product.

The grinding is performed almost exclusively in mills equipped with steel balls, similar to those in general use for cement grinding. The long horizontal, cylindrical mills, which originated in Denmark, render especially good service. Mills are tightly inclosed and ventilators carry off the dust to suitable chambers. The standard of fineness requires a product of which 75 per cent can pass through a sieve with a mesh of 0.17 millimeter (0.0067 inch).

There are 7 steel works in the country using the basic process. In addition to the slag which they furnish, there is an annual import of about 100,000 tons of crude slag, nine-tenths of which comes from French works. Slag is ground in 5 steel works and in 6 other establishments devoted to the manufacture of fertilizers. The preparation of Thomas meal occupies 300 workmen and requires a total of 2,000 horsepower. The domestic consumption is not much below 100,000 tons. In 1910 the export attained 521,500 tons, with an average value of \$8.59 per metric ton.

The chief purchasers were as follows:

Countries.	Metric tons.	Countries.	Metric tons.	Countries.	Metric tons.
Germany.....	330,300	France.....	15,400	Portugal.....	4,200
Italy.....	45,700	United States.....	9,000	Australia.....	2,700
Russia.....	29,100	Spain.....	7,600	Austria-Hungary.....	2,100
Netherlands.....	23,700	India.....	4,900	Cape Colony.....	1,700
Great Britain.....	21,400	Sweden.....	4,500	Dutch colonies.....	1,700

The prominence of Belgium in this field will be recognized when comparison is made with Germany, which in 1911 had a net export of 95,000 tons of Thomas meal.

FLUOSILICATES—COPPERAS—COPPER.

As noted above, in Belgian superphosphate works great care is taken to withdraw from the operation all traces of fluorine compounds. Primarily intended as a sanitary precaution, this has led

to the systematic manufacture of a valuable by-product, sodium fluosilicate. The current of gas issuing from the ventilators is directed through wooden towers or galleries containing quartz fragments. The hydrofluoric acid present is transformed into silicon tetrafluoride. In company with the silicon fluoride already liberated in the primary reaction, it next reacts in an absorption chamber with water, in finely divided spray, and hydrofluosilicic acid is formed. This dissolves in the water present, and an acid solution of 5° Baumé is withdrawn from the chamber. On the addition of a salt solution, sodium fluosilicate is precipitated. There are two factories making a specialty of the production of this compound. The annual output is about 200 tons, part of which is exported to Germany. This fluosilicate is used in the enameling of iron utensils and in the manufacture of milk glass, for which purpose it advantageously replaces cryolite. There is also a growing demand for solutions of hydrofluosilicic acid for disinfection purposes, for the removal of lime from hides, and in connection with the electrolytic precipitation of lead.

Ferrous sulphate is produced in five Belgian factories, the annual output exceeding 5,000 tons. Apart from the direct manufacture by treating scrap iron with sulphuric acid, there is a certain amount recovered from the acid waste water of the larger nail factories at Fontaine-l'Éveque. At Ghent the systematic lixiviation of pyrites cinder has been used with success. The product is used chiefly in Belgium itself as a disinfectant and as a fungicide in fruit culture. A certain amount is employed in making colcothar. Ferric chloride is produced in a single factory, which furnishes annually 65 tons.

A considerable amount of copper is recovered from the cupriferous pyrites employed in the Belgian sulphuric-acid works. Where the percentage of copper is low, the cinder is extracted with acidulated water, and scrap iron is introduced to effect the precipitation. When larger amounts of copper are present in the cinder it is roasted in muffle furnaces with rock salt. The resultant product is thoroughly leached with acidulated water. The solution contains nearly all the copper originally present in the form of chloride and saltpeter. From the solution it is precipitated by the addition of iron. The cement copper thus obtained in the form of powder is collected and fused. The crude metal contains from 75 to 90 per cent of pure copper. Much of it is exported for refining, Belgium itself possessing no works for the metallurgical treatment of copper. The remainder serves for the manufacture of copper sulphate. Five factories produce this salt, and the annual output is over 2,500 tons. Three-quarters of this is exported to France for use as a fungicide in vineyards.

About 50,000 tons annually of cinder are submitted to the cementation process. The residual purple ore is free from sulphur and is in demand for blast furnaces.

THE SODA INDUSTRY.

The most interesting feature connected with the development of technical chemistry in Belgium is the fact that it is the birthplace of the ammonia-soda process. The fundamental principle of this remarkable process was outlined in England as far back as 1838. Repeated attempts were made for a quarter of a century in England, France, and Germany to build up a successful industry, but in vain.

Finally, in 1863, Ernest Solvay took up the problem. In his factory, at Couillet, near Charleroi, he successfully perfected the various steps of the process, and shortly placed it on a remunerative basis. By 1873 the time-honored Leblanc soda method of producing soda was seriously threatened, and branch factories for ammonia soda were established in various countries. Ten years later it was recognized on all sides as successful. Since then no Leblanc plants have been constructed, and the existing works are gradually being dismantled. Out of a total annual production for the world of over 2,000,000 tons of soda, it is estimated that only 100,000 tons are produced by the old method. Solvay's success was due to the invention of apparatus admirably adapted for the new class of reactions when operated on a large scale and to a remarkable coordination of all phases of the manufacture, involving a relatively insignificant loss of ammonia.

ORGANIZATION OF THE SOLVAY CO.

Ammonia soda can be manufactured most advantageously where saturated salt springs are available. This fact has prevented Belgium from becoming as great a center of the soda industry as otherwise would be the case. Its supply of salt for this purpose comes from France. The Solvay Co. has, in consequence, extended its operations to other lands, and it now constitutes the most powerful international manufacturing organization in the whole domain of chemical industry. The original establishment at Couillet has not been materially enlarged, except to provide for the electrolytic manufacture of chlorine and caustic soda. It now employs 520 workmen. In France the company controls the large works at Dombasle and Salin-de-Giraud, employing 2,500 operatives, and manufacturing over 150,000 tons of soda, nearly enough to supply the domestic demand. The English branch, Brunner, Mond & Co., employs over 4,000 operatives in 5 large works, and produces annually over 200,000 tons of soda, nearly one-half of the total English output. In 5 German factories, utilizing 21,000 horsepower and employing 5,000 workmen, the company manufactures over one-half of the soda required in the Empire. The factory at Torrelavega, in Spain, has 600 workmen, and supplies the entire demand of the country. The Russian factories number 3, with 2,500 workmen. Those in Austria-Hungary number 5. The 2 American establishments at Syracuse, N. Y., and Delray, Mich., rank among the largest in the world. In addition to the above list of works under the control of the company there are ammonia-soda factories in Germany, France, and the United States, employing modified methods, such as the Honigmann process and the Mallet-Boulouvard system.

The Belgian works at Couillet are regarded as model chemical factories. The 8-hour workday has been introduced, and in diversified provision for the comfort and welfare of employees they compare favorably with the best examples in Germany.

THE COUILLET WORKS—FOREIGN TRADE.

From the technical standpoint the Couillet works are regarded as presenting the highest possible degree of efficiency under existing conditions. The loss of ammonia is now reduced to 1 pound of am-

monium sulphate per 100 pounds of soda. Thirty years ago it was 4 pounds. For the same weight of soda 180 pounds of rock salt (95 to 98 per cent) are required. The consumption of limestone is 80 pounds, of coal 80 pounds, and of coke 15 pounds. This represents a total cost of production, under existing prices, of about \$9.50 per metric ton. There is thus a wide margin between current rates for soda ash and the cost of manufacture. The influence of the international union of Solvay enterprises has been mainly instrumental in maintaining a rate during late years that has barely allowed existence to surviving Leblanc works, although less than half the price that prevailed 40 years ago.

In one Belgian factory soda is still produced by the roasting of cryolite with limestone. The product on lixiviation yields a solution of sodium aluminate. Limekiln gases are passed through this and precipitate aluminum hydrate. The residual solution of sodium carbonate is then evaporated. The process yields a very pure soda ash.

Belgium carries on a considerable foreign trade in soda ash. In 1910 the imports were 28,600 tons, of which 21,800 tons came from France and 5,900 tons from Germany. The exports were 37,600 tons. Italy was the most important purchaser, taking 9,900 tons. Then followed, in order, the Netherlands, Denmark, Sweden, Norway, Turkey, Portugal, Spain, Greece, Egypt, Russia, etc. The average price of exported soda ash was \$20.75 per metric ton. The large domestic consumption is due chiefly to the needs of the extensive textile industries of Belgium for a variety of compounds derived ultimately from soda. Considerable amounts are absorbed by the glass works, especially by those producing crystal.

SAL SODA—SODIUM BICARBONATE—CAUSTIC SODA.

The domestic demand for bicarbonate is met chiefly by the Solvay works. Sal soda, however, is produced by over 20 small factories. In addition to pure soda crystals there is an extensive manufacture of a mixed salt containing more or less sulphate, and several factories, in addition, prepare Glauber's salt. The annual output of all of these different salts is estimated at 40,000 tons.

There is an annual production of about 2,000 tons of solid caustic. Some small factories still prepare caustic soda from soda ash, with the aid of lime, but most of the above quantity is supplied by the Solvay Co., which has a separate factory at Jemeppe for the electrolytic preparation. The company owns the patents of Castner and Kellner for Europe, and not only employs their methods in their various subsidiary establishments, but also issues licenses to a number of chemical firms scattered over the Continent. At the Jemeppe works the Castner-Kellner method is somewhat modified. In place of double and triple cells, with a salt solution in the cathode compartments, use is made of large single cells containing salt solution alone. A current of mercury enters slowly on one side of the cell, while a layer of sodium amalgam (0.2 per cent Na) flows off on the other side. The salt solution moves in the opposite direction. Decomposition of the amalgam by the aid of steam, with formation of caustic soda, takes place in a separate vessel, and the mercury is conducted

back to the cell. This Solvay modification requires a higher electric tension than is needed for the operation of a Castner-Kellner cell, but the construction and operation are much simpler. Solutions containing over 20 per cent of NaOH are easily obtained.

BLEACHING POWDER.

The chlorine liberated in the electrolytic process at Jemeppe and that obtained by the Deacon method at Droogenbusch is used exclusively in the manufacture of bleaching powder. The annual production exceeds 6,000 tons and meets domestic needs. Two factories prepare solutions of bleaching powder, furnishing annually about 1,600 tons. In 5 factories sodium hypochlorite is made, the output being about 500 tons annually.

It is worthy of note in this connection that Solvay attempted, from the earliest years of the successful solution of the ammonia-soda problem, to develop a technical process for saving chlorine from the waste calcium chloride of the manufacture, thus utilizing both constituents in the salt originally employed. No practical method has thus far been evolved. Equally unsuccessful have been the long-continued efforts to secure chlorine or hydrochloric acid, on an economic basis, from the enormous quantities of magnesium chloride (500,000 tons annually) that are a waste product of the Stassfurt potash works.

SODIUM SULPHIDE AND SULPHITES—MAGNESIUM SULPHATE.

There is an annual production of about 150 tons of the impure sulphide obtained by fusing sulphur and soda. The product is exported chiefly to Argentina, where it is used as a sheep wash.

Sodium bisulphite in solution is manufactured to the extent of 2,500 tons annually. Most of this is exported and destined for use in washing raw wool. There is also a production of about 800 tons of calcium-bisulphite solution. This, as well as sulphurous acid in solution, is used in the country itself for the cleansing of beer casks and for dissolving gelatine. Sulphur dioxide is obtained by burning Italian sulphur.

The technical grades of magnesium sulphate and Epsom salts are manufactured in 2 factories with an output of 1,700 tons. About two-thirds of this is exported. Stassfurt kieserite forms the raw material.

POTASH SALTS—CAUSTIC POTASH.

The utilization of the potassium compounds in wool grease and in the residues from beet-sugar manufacture is followed with unusual care in Belgium, and with a fair profit despite the competition of Stassfurt potash deposits.

The evaporation of the wash water and the calcination of residues is carried on in 2 large works engaged in the scouring of wool, and in 2 small factories that collect the solutions from various sources. They produce annually about 1,100 tons of crude potassium carbonate.

In 7 distilleries devoted to the production of alcohol from the molasses of beet-root sugar works, the vinasse, or liquid residue

from the stills, is evaporated to dryness and calcined. The amount of potassium salts in the crude product ranges from 40 to 70 per cent. On an average 100 pounds of molasses yield 10 pounds of this impure salt. The annual product is about 4,000 tons. There are 3 refineries that treat the crude material from both sources and obtain from it potassium carbonate, in varying degrees of purity, by lixiviation and crystallization. It is possible to secure a 95 per cent salt, but the bulk of the product of the refineries contains 80 per cent of potassium carbonate. The annual output of about 2,000 tons is used chiefly in the manufacture of soft soap.

A single factory at Antwerp produces solid caustic potash to the extent of 500 tons annually. The manufacture is becoming unremunerative, as caustic potash prepared by the electrolysis of potassium chloride in Germany is now being freely exported. In 1911 Belgium purchased 7,800 tons of caustic potash from its neighbor.

SALTPETER—SALT—SULPHUR.

Five factories in Belgium are engaged in the conversion of sodium nitrate from Chile, with the aid of potassium chloride from Stassfurt, into saltpeter. Three of these factories are connected with the German syndicate for controlling the production of this salt. The annual production is about 2,500 tons. One-third is exported to the Orient and South America. The consumption of saltpeter is steadily declining with the more and more limited use of black gunpowder.

There are about 40 salt works in Belgium devoted to the refining of imported salt. Only 6 of these produce over 1,000 tons annually. The number of workmen employed is 210, and the yearly output is 30,000 tons. In 1910 Belgium imported 64,000 tons of refined salt, chiefly from France, Great Britain, and Germany. The imports of crude salt were 142,000 tons, of which the bulk came from France and Germany, although 10,000 tons were received from Tunis.

Belgium consumes annually about 15,000 tons of sulphur, supplied mostly by Italy. The large sulphur refineries of Koch and Reis at Antwerp and Dumkerque are among the best equipped in Europe. They produce annually about 7,000 tons of sublimed and stick sulphur.

ALUMINA AND ALUMINUM SULPHATE.

The Société Anonyme D'Aluminium, at Selzaete, has introduced into Belgium the Peniakoff process for treating bauxite, and manufactures on an extensive scale alumina, aluminum hydrate, sodium aluminate, and various salts of aluminum, especially the sulphate, as well as metallic aluminum. The firm employs 600 operatives and uses 70,000 tons of raw material annually. Bauxite comes from the Var deposits in France. The characteristic feature of the Peniakoff process is the use of sodium sulphate instead of carbonate for transforming the mineral into soluble sodium aluminate. A distinct economy in cost of production is claimed for this method, and an excellent grade of hydrate is produced. The residual solution, after the precipitation of aluminum hydrate with a current of carbon dioxide and filtration, is used to prepare caustic and sal soda. Penia-

koff has introduced into paper mills the use of a mixture of sodium aluminate and resin, instead of aluminum sulphate and resin soap, for the sizing operation. After this addition has been thoroughly incorporated sulphuric acid is added to bring about the formation of the sulphate.

In this establishment aluminum sulphate is no longer made by the action of acid upon the hydrate, obtained as described above. Roasted bauxite is now finely ground and introduced into cast-iron vessels lined with lead and resistant brick. Here it is exposed to the action of the sulphuric acid (52° Baumé), at 100° C., under a pressure of 4 atmospheres. The reaction lasts only a few minutes. Water is added to the product, and the solution of 30° Baumé is allowed to settle for a few days. The clear liquid is drawn off, concentrated to 42° Baumé, and allowed to solidify in shallow vats. Mother liquors are removed by handling in a hydraulic press, under a pressure of 300 atmospheres. The white salt, as secured in this manner, contains less than 0.05 per cent of iron. It is supplied to paper mills in the form of blocks, and also ground to a powder. The residues in the clarifying vats are exhausted with boiling water, and the filtered solution is used for making potash alum.

A complete removal of iron from the clarified solution is effected at no great expense. All iron present in solution is brought to the ferric condition by oxidation with a bleaching-powder solution. Precipitation in the form of Prussian blue is caused by the addition of exactly the requisite amount of ferrocyanide. The operation is one of extreme delicacy, as no excess of calcium hypochlorite or ferrocyanide is permissible. Filtration is effected both by centrifugals and by the use of porous cylinders of magnesium silicate. Solutions of aluminum sulphate, purified in this manner, are evaporated to 52° Baumé and allowed to solidify in lead pans. The trace of iron present is usually 0.0005 per cent.

The factory for this special manufacture of sulphate, with its total equipment, including an engine of 30 horsepower, costs \$22,000 and treats 2.5 metric tons of bauxite daily. From this amount of raw material there is a daily production of 4.7 tons of aluminum sulphate free from iron, 4.4 tons of sulphate containing 0.02 per cent of iron, and 0.86 ton of potash alum. The entire cost of production, including packing in casks, interest, amortization, etc., is as follows per metric ton: Aluminum sulphate, pure, \$12.50; aluminum sulphate, 0.02 per cent iron, \$11.19; potash alum, free from iron, \$19.28.

The current wage rate is 60 cents per day. The cost of materials per metric ton is as follows: Coal, \$2.38; bauxite, \$7.62; sulphuric acid, 60° Baumé, \$4.28; bleaching powder, \$47.60; potassium ferrocyanide, \$285; potassium sulphate, \$38. The greater portion of the aluminum sulphate made in Belgium is exported. Great Britain, Scandinavia, South America, and the Orient are the chief purchasers.

ALUM—PHOSPHORUS AND PHOSPHORIC ACID.

The manufacture of potash alum, apart from its production in connection with aluminum sulphate, as noted above, is carried on in two factories. In one, at Ampsin, the local aluniferous schists are employed as raw material. The other, at Ruysbroek, uses alunite imported from Tolfa, Italy. The annual production reaches 1,800

tons, and nearly all is exported. These factories find competition with English works increasingly difficult, and they have to contend with the growing tendency to employ aluminum sulphate as a mordant.

The factory at Selzaete produces regularly barium aluminate, aluminum chloride, and aluminum fluoride. In a factory at Baelen there is a somewhat extensive manufacture of artificial cryolite, or opaline, and of hydrofluoric acid. The annual output of the latter is about 75 tons.

A single factory, at Angre, is devoted to the production of phosphorus in both modifications by the customary method of distilling phosphoric acid with carbon. A part is employed in preparing copper phosphide (about 25 tons annually) for use in making phosphor bronze. Most of the output is absorbed by the domestic match industry. There is a small export to the Orient. There are 4 factories occupied with the production of phosphoric acid from low-grade domestic phosphatic rock. In 3 works the acid is used chiefly to manufacture double superphosphates. The annual production of the latter is about 15,000 tons. The best grades, containing 42 per cent to 50 per cent of P_2O_5 , are largely in demand for export to distant points in order to counterbalance high freight charges. About 800 tons of citrate-soluble phosphate are secured as a by-product. In one factory alkaline phosphates are a specialty. The annual output of ammonium phosphate reaches 750 tons; that of sodium phosphate 3,000 tons. Two-thirds of the latter is exported to Germany for use in silk and cotton mills.

PIGMENTS.

The manufacture of white lead is well developed and centers about Courtrai. Of the 7 factories the largest, at Anderlecht, has a productive capacity equaling that of all its rivals combined. The industry occupies 400 workmen and utilizes 440 horsepower. The daily wage ranges from 50 to 70 cents. Much work is done by the piece. The Dutch method of manufacture is in general use. At Anderlecht a single carbonating compartment receives a charge of 35 tons of lead. There is a general use of modern equipment for preventing the respiration of particles of lead compounds by operatives at the different stages of manufacture. A large proportion of the product is ground with oil before entering into commerce. Very rigid regulations were issued in Belgium in 1910 with regard to the sale or transport of white lead in the dry form. Those using it in this condition must be specially licensed, and no one without a license is permitted to purchase the article. The annual product is about 15,000 tons, of which about one-half is exported. Canada and Argentina are important purchasers. The factories in question produce also about 1,500 tons of red lead, of which one-half is exported to France, and a smaller amount of litharge for domestic use.

The well-known company of La Vieille-Montagne conducts a finely equipped factory for the manufacture of zinc white in connection with its large zinc works. About one-third of the product is ground with oil—with poppy oil for the finer grades and linseed oil for the cheaper grades. The annual production is about 10,000 tons. The major part is exported, largely to France and England.

A large factory near Louvain manufactures annually about 16,000 tons of lithopone, using German heavy spar and residues from the zinc works. About one-half of the output is exported, largely to Great Britain, Spain, and the United States.

There are 3 factories occupied with the manufacture of ultramarine, giving occupation to 200 workmen and utilizing 310 horsepower. Use is made of German infusorial earth and English kaolin. Most of the soda required is also imported, as Leblanc soda is preferred in the Belgian works. About two-thirds of the annual production of 2,000 tons finds a foreign market. Competition is keen between Belgian and German manufacturers of ultramarine.

There are 11 establishments devoted to the production of ochers, rouge, etc. Most of the raw material is found in local deposits between Liege and Namur and near Spa. A certain amount of ore is also brought from Spain and Sweden. About 600 tons of rouge and colcothar are manufactured annually from ferrous sulphate. The production of ochers and similar iron pigments reaches 6,000 tons. The bulk of these pigments is exported. There are also some 5 factories that manufacture chrome colors, Schweinfurth green, and similar pigments, with an annual export of 1,200 tons.

COMPRESSED GASES—BARIUM SULPHATE—BORAX.

One firm at Brussels, employing 25 workmen, supplies electrolytic oxygen and hydrogen in steel flasks, under a pressure of 120 atmospheres. Another, near Liege, makes a specialty of liquid sulphur dioxide, furnishing 80 tons per annum. About one-half of this is exported. There is a growing tendency in Belgium to substitute the dioxide for sulphites and bisulphites in connection with bleaching and similar operations. Three factories manufacture liquid carbonic acid to the extent of 370 tons annually. In one factory the gas is obtained as a by-product of fermentation, in the others by the calcination of magnesite and limestone. The local production is insufficient for the needs of the country, and over 900 tons annually are imported from Germany, where the gas is collected from natural sources. Anhydrous ammonia is manufactured by the Solvay company and by a firm at Nimy. The annual output is 50 tons.

There is an extensive deposit of barium sulphate at Faleurus, which furnishes material for three factories located in the vicinity. A fourth factory uses German spar. The extraction of mineral occupies 180 workmen, and 85 more are engaged in the four factories in the washing, grinding, etc., of the material. The annual production of powdered sulphate is over 26,000 tons. About one-half is used in the country itself for the manufacture of lithopone, barium aluminate, etc., and for mixing with pigments, paper, caoutchouc, etc. The export goes largely to Great Britain.

A single factory uses South American horo-natro-calcite as raw material, and produces annually 900 tons of borax and 60 tons of boric acid.

WHITE ARSENIC—ZINC CHLORIDE—HYDROGEN PEROXIDE.

Two factories connected with lead works are engaged in the production of arsenic trioxide from the residues obtained in treating lead ores. The annual output of 2,500 tons is sent for the most part to Germany (460 tons in 1911), Great Britain, and the United States.

There is a limited production of about 300 tons of zinc chloride annually in connection with the manufacture of zinc white.

The production of hydrogen peroxide is effected in a factory at Ghent by the direct union of hydrogen and oxygen, according to the recent process of A. Hemptinne. A mixture of the two gases, containing 4 per cent of oxygen, yields the peroxide in large amount when exposed to the action of the electric current. The process is one of promise on account of its simplicity as compared with the prevalent methods based upon the use of the peroxides of barium or sodium. It is to be noted, however, in this connection that German chemists are steadily perfecting processes for securing hydrogen peroxide by the continued electrolysis of sulphuric acid after its transformation into persulphuric acid, and also by the use of solid persulphates and of perborates.

CEMENT.

The manufacture of cement has rapidly developed of late years, so that now Belgium has become one of the leading factors in the international trade in this article. Cement factories number 50, employ 4,000 workmen, and utilize 7,700 horsepower. The annual product exceeds 750,000 tons. Belgium has become one of the leading factors in the international trade in this article. Belgium's net export was 701,000 tons in 1910, as compared to 483,000 tons for Germany. There was even a net export of 88,000 tons to Germany. The rivalry of Belgian cement is felt by German producers in all foreign markets. The chief purchasers of cement in 1910 were as follows:

Countries.	Metric tons.	Countries.	Metric tons.
Argentina.....	145,000	Spain.....	25,000
Netherlands.....	130,000	Portugal.....	18,000
Germany.....	88,000	Turkey.....	17,000
United Kingdom.....	54,000	United States.....	15,000
Brazil.....	51,000	Chile.....	13,000
Egypt.....	27,000	Dutch colonies.....	10,000
France.....	25,000		

The average price was \$4.75 per ton. The extent to which Belgium dominates the South American market is remarkable. A syndicate exists among the Belgian manufacturers of so-called natural cement, but it has been unable to maintain prices, and its continued existence is doubtful.

MATCHES.

The manufacture of matches forms an industry of considerable importance, contributing largely to international trade. There are 13 factories, situated mostly in the neighborhood of Grammont. The largest factory, that of Caussemille, Roche & Co., at Ghent, has 700 operatives. Nine factories make wooden matches only; the others include wax tapers. Russian aspen serves almost exclusively as raw material. The cost, delivered at factories, is \$6.56 per cubic meter (35.3 cubic feet). Belgium is one of the countries where the manufacture and use of matches made with white phosphorus is still permitted. The domestic use of such matches is, however, rapidly diminishing. The exportation is still an important feature of trade.

There are three distinct types manufactured at present: The old-fashioned sulphur match, with head of white phosphorus and sulphur; the English match, with head of phosphorus, potassium chlorate, and paraffin; and the modern safety or Swedish match. The production in 1908 was as follows: Sulphur matches, 11,520,000 boxes of 340 matches each, valued at \$106,000; English matches, 179,000,000 boxes of 55 matches, valued at \$233,000; Swedish matches, 222,000,000 boxes of 55 matches, valued at \$287,000; wax tapers, 5,000,000,000, valued at \$154,000; total value, \$780,000.

The value of the product in 1911 was estimated at \$1,250,000. The sulphur matches are for local consumption. Eighty per cent of the English matches are exported and 65 per cent of the Swedish. Nearly all of the tapers are shipped abroad, chiefly to Great Britain and Australia, the value of the exports in 1910 reaching \$153,000. Great Britain purchased over one-half of the wooden matches exported. The other leading purchasers were France, Turkey, the United States (\$36,000), Egypt, India, Porto Rico, Spain, and the Netherlands. There is very keen competition in the foreign markets between the manufacturers of Belgium and those of Germany and Sweden. The latter country even exports to Belgium, the value of such exports in 1910 being \$67,000. The competition of Japanese wares in the Orient is also felt more and more each year. Eleven of the Belgian manufacturers are united in a syndicate for the purpose of maintaining domestic and export prices. The capital of the syndicate is \$1,350,000.

GLASS.

The glass industry is also one of international importance, and its development has meant much in the consumption of chemicals. Over 31,000 operatives are employed in 69 factories, utilizing 25,000 horsepower. The chief expansion of late years has taken place in the manufacture of glassware for ornament and table use. The exports in 1910 were as follows: Plate glass, 41,000 tons; window glass, 215,000 tons; bottles, 2,500 tons; tableware, 30,500 tons; miscellaneous, 3,700 tons. The total output was valued at \$16,300,000. The exports of plate glass exceed 90 per cent of the output, that of window glass 95 per cent, and that of tableware 75 per cent. There is an annual import of 16,000 tons of bottles.

The Belgian glass works use annually 1,200,000 tons of coal. They consume 17,000 tons of soda ash, 109,000 tons of sodium sulphate, 116,000 tons of lime, and 344,000 tons of sand. Nearly all the sand used is of domestic origin. The choicest grade—that of Fontainebleau, containing 0.005 to 0.015 per cent of ferric oxide—costs 48 cents per ton at the pits. Campine sand, with 0.04 per cent Fe_2O_3 , costs 29 cents and ordinary sand 19 cents.

Nine of the leading plate-glass establishments in Belgium belong to the powerful international syndicate, the Convention Internationale des Glaceries. The organization includes 15 other firms in France, Germany, and Italy. One-half of the world's output of plate glass is controlled by this syndicate. The Belgian works supply one-quarter of the world's demand. Only 10 per cent of this product is consumed at home. Despite the strong position of the Belgian industry, American manufacturers are represented at Brussels and sell annually \$15,000 to \$20,000 worth of glassware.

PAPER—COAL GAS AND BY-PRODUCTS.

The paper industry is highly developed and is another leading consumer of chemical products. There are 21 mills producing finer grades, 9 mills devoted to wrapping paper, 12 to pasteboard, and 2 to imitation parchment. Wood pulp is manufactured in 3 additional factories. The net import of wood pulp was 90,000 tons in 1910. The entire industry requires 6,000 operatives. The exports in 1910 reached \$6,400,000, against imports of \$2,500,000. The United Kingdom takes one-third of the Belgian export. The next most important purchasers, in order, are Japan, the Netherlands, Turkey, Argentina, Brazil, Australia, the United States, and France.

The number of gas works in Belgium is 67, and the coal consumed annually exceeds 700,000 tons. Domestic coal from Mons constitutes 30 per cent of this amount. Germany supplies 40 per cent to works in the east and France 22 per cent to those in the west. The remainder comes from England. The average cost, delivered, is \$2.41 per metric ton. The annual output of coke is 480,000 tons. Great care is taken in the Belgian works to utilize all by-products. In addition to what they yield are the contributions from coke works, built for the recovery of tar, ammonia, etc. These latter produce annually about 1,250,000 tons of coke. The Semet-Solvay type of coke oven is the predominant type. The Evence-Coppée and the Colin systems are also used to some extent.

Among the minor by-products are graphite, annual output 500 tons; sodium ferrocyanide, 300 tons; ammonium sulpho-cyanide, 2,000 tons.

AMMONIA AND AMMONIUM SULPHATE.

In several gas works the Solvay method for securing pure ammonia water is used, and the operations are carried on under the direction of the Solvay company with its special apparatus. The larger gas works manufacture ammonium sulphate directly. The annual output of sulphate from gas works exceeds 4,000 tons. From coke ovens there is an additional quantity of 10,700 tons, making a total of 14,700 tons. This does not suffice to meet the demands of domestic agriculture, and there is a net import of 2,500 tons from Germany. The Belgian coke works are now tending to an increased production of sulphate by the direct method, the oven gases being in part brought immediately in contact with sulphuric acid.

As now practiced the current of gas from the ovens is conducted through cooling columns, so that the temperature is lowered to 30°, and then through a Pelouze tar separator. This removes the heavier tar oils, such ammonium salts as NH_4Cl , most of the water, and with it 25 to 75 per cent of the free ammonia. The gas current, containing the remaining ammonia and the lighter hydrocarbons, is next heated to 60° C. and passed through an absorption apparatus containing sulphuric acid of 60° Baumé. Solid ammonium sulphate separates out and is dried in a centrifugal. The benzine, etc., still remaining in the gas, is removed by passing through condensing tubes. Ammonia water obtained in the coolers and tar separator must be subjected to distillation as formerly in order to secure the ammonia, but as the amount of accompanying water is only one-fifth of that necessarily present when absorption is effected by means

of scrubbers, etc., there is a notable economy in the use of fuel for distillation and in the handling of residual waste water.

In connection with the production of ammonia from the distillation of coal, it is worthy of note that ammonia is secured in Belgium by the method of J. Effront from schlempe or the residues of the beet-root sugar manufacture. The raw material is thoroughly dried and then distilled at 500° C. in a current of superheated steam. The addition of a certain amount of resinous matter facilitates the transformation of the nitrogenous compounds present into ammonia. Under the above conditions nearly all nitrogen in the residues is secured in the form of ammonia. Ordinarily distillation yields chiefly a mixture of organic amines.

BELGIAN TAR WORKS—ANILINE DYES.

The six tar works in Belgium are well equipped and handle annually over 100,000 tons. A little less than half of this comes from abroad, chiefly from cities on the coast of the Baltic, the Atlantic, and even the Mediterranean. An additional factory is devoted to the refining of naphthalene and of anthracene. The annual output is as follows, in metric tons: Benzine, toluene, etc., 4,800; carbolic acid, 250; naphthalene, crude, 9,000; heavy oils, 22,000; anthracene (35 per cent), 4,500; pitch, 62,000.

About two-thirds of the naphthalene is refined. A large share of the anthracene is also refined to the 80 per cent grade. All of these products except pitch are exported in quantity. Much of the creosote oil goes to France. The United States purchases about 1,000 tons annually of naphthalene. Pitch is imported in large amounts, Germany furnishing 38,000 tons. Its chief use is for manufacturing briquets of coal dust. The Société Anonyme des Agglomérés Réunis du Bassin de Charleroi, with works at Marcinelle and Chatelinan, is the leading firm in the Belgian tar industry, in which over 600 workmen are engaged.

Little effort is made in Belgium to manufacture coal-tar colors and compete with the great works of France and Germany. Two small factories make quinoline yellow, various nigrosines, soluble blues, etc. The largest of these, at Hoeren, employs over 100 operatives, and exports annually in excess of 500 tons. The great mass of dyestuffs comes from Germany. In 1911 the purchases were: Aniline dyes in general, 2,000 tons; alizarin, 92 tons. The annual consumption of German synthetic indigo is 700 tons. Belgium conducts a large trade in dyes and coloring material, apart from her own important production of mineral pigments. In 1910 the total imports of colors and pigments, excluding indigo, amounted to \$6,800,000, and the exports to \$11,406,000. The sales of German indigo reached 4,665 tons, of which nearly all was taken by China.

WOOD DISTILLATION.

Wood distillation is carried on extensively in Belgium, especially in the forest region along the French frontier. There are eight factories employing 455 workmen, with a motive power of 530 horsepower. Beech and oak are the chief varieties of wood used. In one establishment spent quebracho chips form the raw material. About 50,000 tons of wood are subjected annually to distillation.

Vertical iron retorts, holding about 175 cubic feet, are ordinarily used for distilling hard woods. Quebracho chips are distilled from large revolving cylinders holding 1,000 cubic feet. Of the eight factories mentioned, four carry on the refining of the primary products. The total annual value of the products reaches \$750,000.

The output of charcoal is 13,000 tons, of which about one-half is exported to France. Most of the wood alcohol is sold in a partly refined condition, for use in making varnish, for fuel purposes, and especially for denaturing ethyl alcohol. In 1910, 56,000 gallons of the impure alcohol were exported, chiefly to France. The average price was 57 cents per gallon. In the same year 69,000 gallons of refined methyl alcohol were imported, three-quarters coming from the United States. The average value was 66 cents per gallon. Two factories are now engaged in manufacturing formaldehyde, chiefly for domestic consumption.

The annual output of calcium acetate is over 2,300 tons. In four factories acetic acid and acetone are manufactured from the domestic and also from imported acetate. Sodium acetate is now produced to quite an extent. The annual product reaches 2,000 tons. Acetic acid itself is manufactured chiefly by the Behrens method. The production of technical acid reaches 2,700 tons. About two-thirds of this is exported to Switzerland, England, and Japan. There is a further production of 500 tons of purified acid for table use, chiefly for domestic consumption.

Acetone is manufactured in increased amounts and used for making chloroform and gelatinizing guncotton. Allylic alcohol is now isolated in technical amounts from the crude wood alcohol obtained by the distillation of quebracho chips.

Acetic ether is manufactured to some extent by a factory for high explosives at Wetteren. It is used as a solvent for guncotton. The wood tar is often used as a fuel under the stills. In one factory beech-wood tar is rectified and creosote and gaiacol are isolated and refined.

TANNING EXTRACTS—SALICIN.

The production of these extracts has grown to be a branch of importance. Two factories, employing 150 operatives and using 600 horsepower, furnish annually about 11,000 tons of extracts in the dry, paste, and liquid forms. About 8,000 tons of quebracho wood are imported from South America for this purpose. Chestnut from France and oak from France and Belgium itself are also used in quantity. The equipment of these factories is almost identical with that of the beet-root sugar factories. Extraction is effected by water and steam, under pressure, in diffusion batteries; concentration is carried on in evaporators with triple effect; and for the final evaporation, in the case of paste or dry extract, vacuum apparatus is employed. About two-thirds of the production is exported. In 1911 the net imports from Belgium into Germany reached 2,300 tons.

The extraction of salicin, a glucoside, from the bark of the *salix rubra* is a specialty in Belgium, where the plant grows abundantly in the valley of the Scheldt. About 500 tons of bark are treated annually. In one factory the aqueous extract, concentrated to 25° Baumé, is produced. In another factory the pure glucoside is obtained by the Crispo process. The entire output goes to England.

SULPHURIC ETHER—FUSEL OIL—ARTIFICIAL SILK.

The factory at Wetteren, mentioned above, produces about 2,500 tons of ether of a technical grade for use in manufacturing explosives and in the making of artificial silk. There is a growing domestic demand for the solvent.

The production of fusel oil in connection with the rectification of spirits is becoming more important. Exports in 1910 reached 75,000 gallons. One-half went to the Netherlands and most of the remainder to the United States. The average price per gallon was \$1.08.

Two factories at Obourg and at Tubize have recently begun the manufacture of artificial silk by the Chardonnet process. They furnish large quantities to the textile works of Belgium.

EXPLOSIVES.

The manufacture and trade in explosives has attained an unusual development in Belgium, despite the absence of any extensive military or naval establishment. This is due partly to the mining interests of the land and partly to the extensive trade in firearms. The manufacture of firearms became a pronounced specialty in and around Liege at an early date, and it has steadily grown of late years. The sale abroad of military rifles, revolvers, and more particularly hunting guns, amounted in value to \$4,750,000 in 1910. This trade to nearly every country on the globe has had its effect on the market for powder, cartridges, and explosives generally.

There are at present 14 companies engaged in the different branches of the industry. They own 21 factories, employ 700 workmen, and utilize 900 horsepower. The annual output exceeds 3,500 tons. Over one-quarter of this is exported.

GUNPOWDER.

Gunpowder is made by 8 establishments, in one of which slow-burning powder alone is produced. The annual output of the latter is 80 tons and of ordinary powder about 2,000 tons. About 200 tons is designed for hunting purposes and 700 tons for military use. The remainder is blasting powder. In 1910 there was a net export of 572 tons, of which 373 tons went to the Kongo colony and the west coast of Africa. The use of ordinary black gunpowder in Belgium itself has fallen rapidly during the past 20 years. The mines now use increasingly large amounts of dynamite and of safety explosives. Smokeless gunpowder for military use has also become more general. A convention exists among the Belgian manufacturers to maintain prices. During the past few years much cheap German powder has entered Belgium. The import in 1910 reached 302 tons, with an average value of 15.8 cents per pound.

Safety explosives, with a base of ammonium nitrate, are now made in 7 factories. The annual output is 500 tons and tends to increase. Ammonium nitrate for use in this branch is now manufactured in one factory by the Ostwald method, oxidation of ammonia being effected by means of catalytic agents. The annual export of safety explosives is about 100 tons. It is much restricted on account of the difficulty of securing transportation on seagoing vessels. Even on the inland waterways of Belgium shipments are not allowed.

CHEDDITE.

Cheddite is now manufactured regularly in a factory at Molenstede recently started by a branch of the French company controlling the patents and the production of chlorates by the electrolytic method in Italy. The manipulation is exceedingly simple. Finely powdered dry potassium chlorate is gradually added to a solution of dinitrotoluene and nitronaphthalene in castor oil at 70° C. The mixture is kept in constant agitation while cooling and yields for the most part a fine-grained powder, which, after standing a few days, can be filled into cartridges. The latter are coated with paraffin. Sodium chlorate is used to some extent in place of the more expensive potassium salt. The current quality of the explosive costs 13.2 cents per pound. This simplicity and ease of preparation, with its consequent cheapness, together with the good keeping qualities of cheddite, have rapidly won for it recognition and a growing market.

SMOKELESS POWDER AND DYNAMITE.

Smokeless powder is manufactured to the extent of about 200 tons. Two firms are engaged in producing this article. A specialty of one firm is tonite, consisting of 4 per cent barium nitrate, 42 per cent saltpeter, and 54 per cent guncotton; it is employed chiefly for blasting purposes. The annual output of tonite is 15 tons and of the ordinary smokeless powder 200 tons. The total amount of guncotton produced annually in the two factories is given at 225 tons. Eight tons find use in the form of collodion.

The factories manufacturing dynamite are 3 in number, and the annual production has reached 750 tons. Their capacity is double this amount and in the course of a few years will be attained, as the quantity used in mining increases rapidly. Much of the refined glycerin used in the works is brought from abroad. A large share of the product is gelatinized. The normal mixture for gelatinization is 93.5 parts nitroglycerin to 6.5 parts guncotton. Belgium imports about 100 tons of dynamite from Germany and exports about 300 tons to Great Britain, Austria-Hungary, and South America.

FIXED AMMUNITION, DETONATORS, ETC.

Closely allied to the production of explosives is the manufacture of fixed ammunition, detonators, fuses, etc. The cartridge industry, like that of firearms, is largely concentrated about Liege, where 5 factories give employment to 1,700 operatives. About 150,000,000 cartridges annually are filled, the value exceeding \$2,500,000. The value of the exports is \$1,930,000. They are shipped to every part of the globe. Seventy tons were imported into Germany from Belgium in 1911, as compared with 13 tons from the United States.

Fuses are made in four factories. The annual output exceeds 92,000,000 feet, valued at \$164,000. Germany purchased 84 tons of Belgian fuses in 1911. Detonators are made in one factory, which produces annually about 20,000,000, valued at \$87,000. Four-fifths of this amount is exported. Percussion caps are manufactured in 2 factories, the annual output being valued at \$23,000. Fireworks are

made in several establishments near the large cities; the output is mostly for the home market. The total annual production is worth \$60,000.

STARCH—GLUE AND GELATIN.

The starch industry is highly developed in Belgium. The chief raw material is rice. The factory at Wygmael is claimed to be the largest in the world. The exports for 1910—12,560 tons—went to nearly all countries. Great Britain took over half, and Switzerland, Brazil, Egypt, Denmark, South Africa, Argentina, and Uruguay were all large purchasers. The export is offset to some extent by an import of 4,880 tons, of which half was cornstarch from the United States and the remainder potato starch from the Netherlands and France.

The manufacture of glue and gelatin is important. The 8 factories employ 400 workmen and utilize 250 horsepower. The 3 largest factories produce together 9 tons of glue and gelatine daily. The firm of Duché, at Point-Brule, has branches in other countries. The bulk of the output is used in the domestic textile and paper industries. There is a net export of over 3,000 tons of glue, the greater part of which goes to Great Britain.

OILS AND FATS.

The country consumed in 1910, 150,000 tons of refined petroleum, of which 60 per cent came from the United States. The remainder was contributed by Roumania, Galicia, and the Caucasus. There is 1 petroleum refinery in Belgium, but the business of refining has largely ceased, and the import of crude petroleum is insignificant. Two factories handle heavy oils and 4 make a specialty of mineral lubricating oils. The annual product is 10,000 tons, of which 70 per cent is exported. A considerable amount of vaseline also is isolated in these works.

Animal fats are employed chiefly in the production of oleomargarin and margarin. Their import reaches 2,000 tons. There is likewise a net import of oleomargarin and similar products amounting to 1,300 tons.

About 5,000 tons of resin are distilled annually in some 10 establishments. The product of nearly 4,000 tons is exported largely for use as a lubricant. Most of the resin comes from the United States. A small portion is contributed by France.

VEGETABLE OILS.

The manufacture of vegetable oils is very important, as there are no less than 160 oil mills. Belgium itself furnishes a large amount of linseed and rapeseed, but the bulk of the oleaginous seeds is imported. In 1910 the net imports were as follows, in metric tons: Castor-oil bean, 10,240; cotton seed, 990; linseed, 70,600; peanuts, 8,100; poppy seed, 3,800; rapeseed, 47,000; sesame, 1,600; divers, 32,000; copra, 19,700; palm nuts, 7,400.

Rapeseed oil is manufactured in 30 mills, several of which refine crude imported oil. The annual output exceeds 20,000 tons. Some is exported, chiefly to Great Britain. The demand for this oil as an illuminant in mines is steadily increasing.

Coconut butter is refined in two factories. One-half of the annual product of 3,000 tons is shipped to Germany. Several factories have been started for the manufacture of corn oil. Belgium purchases corn largely from Argentina.

The annual output of oil cake is estimated at 84,000 tons, all of which is absorbed by the agricultural interests of the land. There is further a net import of 175,000 tons of oil cake, consisting chiefly of cottonseed meal from the United States.

In 1910 the net imports of vegetable oils were as follows, in metric tons: Corn oil, 720; cottonseed oil, 3,050; olive oil, 2,060; palm oil, 11,200; poppy oil, 900; divers, 6,200. The net exports in the same year were as follows: Castor oil, 3,580; coconut oil, 3,700; linseed oil, 9,800; peanut oil, 250; rapeseed oil, 460; sesame oil, 730.

MARGARIN—CANDLES—SOAP.

The production of margarin and other artificial butters has become an important industry of late years. There are now 16 factories, of which three are devoted to the manufacture of oleomargarine. In 1910 the 13 other factories produced 10,074 tons, of which 9,583 tons were classified strictly as margarin. The materials used were as follows, in metric tons: Oleomargarin, 3,071 other fats, 1,641; pure butter, 50; milk, 5,325; cottonseed oil, 2,648; peanut oil, 181; sesame oil, 501; other oil, 536. There was a small export of 533 tons and an import of 13 tons.

The stearin industry of Belgium has reached a high state of perfection, and its products are well known in most countries. There are 4 factories. The most important, the Manufacture Royale, at Brussels, employs 380 operatives and uses 10,000 tons of raw material annually. The output includes 5,000 tons of stearin, 2,000 tons of candles, 3,000 tons of olein, and 400 tons of glycerin. Glycerin is refined here and in the other works, a certain amount of crude glycerin, also, being imported for the purpose. Belgium exports about 70 per cent of the total output of candles. In 1910 the shipments reached 4,250 tons. Argentine, India, and Turkey were the chief purchasers, but sales were made to nearly every country. There is an annual import of 7,000 tons of stearin, 2,500 tons of olein, and 800 tons of refined glycerin.

The soap industry is relatively less developed. There are 12 factories producing hard soaps, and there is an increasing variety of toilet soaps. The total annual output is estimated at 5,000 tons. In 4 other establishments soap powder is produced to the extent of 2,000 tons. Soft soap is made in a number of small works. Domestic consumption is, however, in excess of the supply. In 1910 there were net imports of 407 tons of toilet soap—chiefly from Great Britain, Germany, and France—143 tons of other hard soap, and 60 tons of soft soap.

Mention should be made in this connection of a factory recently started at Verviers for extracting wool grease by the American method of treating wool with benzine. The annual output of lanolin exceeds 1,000 tons. Much of this is exported to the United States. The value of such exports was \$63,000 in 1910 and \$43,000 in 1911.

The firm of A. van de Kerckhove, in Brussels, has an international reputation for its manufacture of neat's-foot oil, highly valued as a lubricant for machines of precision. It employs 90 operatives and prepares a variety of oils from the hoofs and bones of different animals.

VARNISHES—PERFUMES—PHARMACEUTICAL PRODUCTS.

There is a moderate production of varnish, chiefly by firms engaged in the manufacture of lubricants or of colors. It is thus far inadequate for domestic needs, and in 1910 net imports reached 933 tons, with an average value per ton of \$347. Great Britain supplies about one-half of the import; the remainder comes from France, Holland, Germany, and the United States. The value of the imports from America was \$40,000.

The manufacture of perfumes and cosmetics is still in its infancy in Belgium, although much is done to meet the domestic demand. As in the case of toilet soaps there is a large import, two-thirds of which is supplied by France. This import in 1910 reached 312 tons, with a value of \$463,000. There was a small export of 21 tons.

There are five establishments in Belgium engaged in the manufacture of pharmaceutical products and pure chemicals. Their operatives number 150. Thus far they furnish only a small part of the domestic consumption. The Belgian pharmacies all display a great variety of products coming from France, England, Germany, and the United States. In 1911 the imports of pharmaceutical preparations from America alone amounted to 38 tons.

SUGAR—COAL.

The manufacture of beet-root sugar is very important in Belgium, and is of special interest to the chemist on account of the current methods of utilizing the residues for the production of ammonia and the cyanides. There are at present 92 sugar factories and 22 large refineries. In 1910 these factories produced 271,300 tons of sugar, of which 108,000 tons were partly refined. The refineries handle 112,000 tons of raw sugar. There was an import of 9,300 tons of raw sugar and 660 tons of refined. The exports included 38,000 tons of raw sugar and 82,000 tons of refined sugar. The excise duties on sugar brought in a revenue of \$3,675,000. The output of glucose amounted to 10,416 tons.

As already noted, the coal deposits of Belgium are relatively of great extent. In 1909 there were 96,616 miners and 6,600 boys employed in the mines. Employees above ground numbered 39,000, including 8,200 women and girls. The average annual wage for the entire force was \$250.12. The output of the 130 mines now in active operation reached 23,518,000 tons, and the average value per ton was \$2.77. In 1910 there was a net import of 1,473,800 tons of coal from adjacent countries. This was offset to some extent by net exports of 545,500 tons of coke and 268,000 tons of briquets.

METALLURGY.

The native ores of Belgium are being rapidly exhausted and the country is depending now very largely on foreign sources to supply

its numerous furnaces. In 1860 there were 11,100 miners engaged in the extraction of ore. Now the number has sunk to 700. This diminution is due in many cases to the exhaustion of the deposits; in others to the increased difficulty and cost of extraction. The following table shows the production in tons in 1909, as compared with maximum yields in earlier years:

Ores.	1909	Maximum yields.	Ores.	1909	Maximum yields.
Iron ore.....	200,000	800,000 (1860)	Calamine.....	.....	62,000 (1850)
Iron ore, manganiferous..	6,270	22,000 (1895)	Zinc blende.....	1,230	23,000 (1880)
Pyrites.....	214	42,000 (1860)	Galena.....	152	13,000 (1870)

Despite this enormous shrinkage in the domestic ore supply, the metallurgical interests continue to expand. They constitute a leading factor in the economic fabric of the Kingdom, and naturally exert a marked influence in favoring the development of its chemical industries.

Iron and steel are the most important products. The 38 blast furnaces, employing 3,874 workmen, turned out 1,616,000 tons of pig iron in 1909. Of the ores used, only 6 per cent came from Belgian mines. The near-by mines of France contributed 60 per cent, and Luxemburg 32 per cent. The remainder came from Germany, Algeria, Norway, Great Britain, Sweden, and Portugal. Imports of pig iron are also growing rapidly. They increased from 384,000 tons in 1908 to 672,000 in 1910.

In the rolling mills there are 162 puddling furnaces and 9,800 workmen are employed. The output in 1909 was 485,000 tons, of which 317,000 tons were in a shaped form. Steel works number 22 and employ 16,000 workmen. They contain 68 Bessemer converters and 25 Martin and other furnaces. The production in 1909 was as follows: Cast steel, 1,580,000 tons; blooms, billets, etc., 866,000 tons; finished steel, 1,265,000 tons. Much of the output is utilized in the vast machine works of Belgium, and there is a heavy export of structural iron and steel, rails, boiler plate, nails, etc.

The zinc industry is also a valuable feature, as one-quarter of the world's production of this metal is supplied by Belgium. There are 492 furnaces in the 13 large works, and employment is given to 7,400 operatives. In 1909 the output of metallic zinc reached 174,000 tons. The ores came largely from Italy, Sardinia, Spain, Portugal, and Algeria. The direct import of American ore has ceased of late years, although zinc dross of American origin is still received. The net export of zinc from Belgium in 1910 was 140,000 tons.

The lead works number 5, contain 32 furnaces, and give employment to 1,860 operatives. Some ore is brought from Australia and France. Refuse from zinc works is a leading raw material. Slags and impure metal from Spain, Australia, and Mexico also come to the Belgian works. In 1909 they produced 40,000 tons of refined lead and 271 tons of silver.

Belgium still depends largely on other countries for a supply of aluminum. The net import in 1910 reached 525 tons. Copper likewise comes entirely from abroad, chiefly from the United States,

the average annual consumption being over 6,000 tons. Belgium is now beginning to receive consignments of raw copper from the Katanga mines in the Kongo colony. The control of this source of the metal may have a material influence in developing those branches which are large consumers of copper.

TRADE WITH THE UNITED STATES.

Inasmuch as Belgium becomes each year more of a distributing point for the world's wares, it is not easy to measure exactly the volume of its trade in chemical products that are purely domestic products on the one hand, or, on the other, are destined for domestic consumption. The available statistics reveal a somewhat extensive movement in both directions between the United States and Belgium. In 1910 the American exports to Belgium included the following:

Articles.	Value.	Articles.	Value.
Animal fats.....	\$1,230,000	Nickel.....	\$168,000
Blacking.....	6,000	Oil cake.....	4,463,000
Bones.....	12,000	Oils:	
Chemicals:		Animal.....	135,000
Calcium acetate.....	611,000	Petroleum.....	3,444,000
Dyes and dyestuffs.....	44,000	Vegetable—	
Patent medicines.....	32,000	Corn.....	9,000
Wood alcohol.....	43,000	Cottonseed.....	105,000
Miscellaneous chemicals.....	40,000	Other.....	3,000
Copper.....	886,000	Paints and pigments:	
Fertilizers:		Lampblack.....	10,000
Raw phosphates.....	448,000	Zinc white.....	19,000
Thomas meal.....	13,000	Other.....	21,000
Glucose and grape sugar.....	33,000	Paraffin.....	233,000
Glue.....	2,000	Paper stock.....	185,000
Graphite:		Perfumery.....	3,000
Crude.....	41,000	Soap:	
Manufactured.....	4,000	Toilet.....	5,000
Grease and soap stock.....	384,000	Other.....	2,000
Isinglass.....	5,000	Spermaceti.....	4,000
Lead.....	3,000	Starch.....	54,000
Linseed.....	14,000	Varnish.....	20,000
Naval stores:		Wax.....	3,000
Rosin.....	717,000	Wood pulp.....	78,000
Turpentine.....	1,181,000	Zinc dross.....	25,000
Tar and pitch.....	6,000		

In this outward movement there is to be noted a decided growth of late years in the export of paper stock and Thomas meal, a still more marked increase in the case of rosin and starch, and an exceptionally large growth in the sales of paraffin and of copper. On the contrary a noticeable decrease is observable in the exports of miscellaneous drugs, wood pulp, petroleum, and such metals as aluminum, lead, nickel, and zinc. It is very marked in the case of cottonseed oil and wax, and still more pronounced in the movement of corn oil and linseed. A somewhat important export of copper sulphate has now totally ceased.

EXPORTS TO AMERICA.

The declared exports from Belgium to the United States in 1911, according to consular invoices, included the following:

Articles.	Value.	Articles.	Value.
Acids.....	\$10,000	Gum copal.....	\$34,000
Aluminum.....	23,500	Gunpowder.....	4,800
Aniline colors.....	140,000	Lithopone.....	25,200
Antimony and products.....	59,000	Linseed.....	693,000
Arsenic.....	18,400	Matches.....	15,800
Artificial silk.....	242,000	Naphthalene.....	34,700
Barium sulphate.....	5,800	Oils:	
Basic slag.....	19,000	Animal.....	2,600
Beeswax.....	2,000	Mineral.....	36,300
Bones.....	30,500	Vegetable.....	528,000
Candles.....	2,400	Lubricating.....	12,000
Cement.....	6,600	Olein.....	5,000
Chemicals, miscellaneous.....	250,000	Ores.....	4,500
Colors.....	31,000	Paper stock.....	531,000
Creosote oil.....	76,000	Paraffin.....	70,000
Fertilizers.....	680,000	Pitch.....	2,600
Gelatin.....	1,800	Seeds.....	200,000
Glue and glue stock.....	181,000	Stearin.....	3,000
Glycerin.....	377,000	Wool grease.....	43,000
Grease.....	1,600		

American statistics for 1910 furnish fuller details on the various chemicals imported from Belgium. They embrace the following:

Articles.	Value.	Articles.	Value.
Aniline salts.....	\$13,000	Gambier.....	\$6,000
Arsenic.....	14,000	Gelatin.....	2,000
Bleaching powder.....	7,000	Gums.....	27,000
Coal tar:		Indigo.....	20,000
Colors.....	64,000	Potash:	
Preparations.....	4,000	Caustic.....	18,000
Products, miscellaneous.....	34,000	Carbonate.....	61,000
Collodion.....	1,000	Quebracho extract.....	59,000
Creosote oil.....	6,000	Sodium salts.....	15,000
Fusel oil.....	33,000	Miscellaneous chemicals.....	132,000

Belgium statistics of exports to the United States for the calendar year 1910 give the following values for certain items: Cement, \$76,000; chemicals, miscellaneous, \$620,000; drugs, miscellaneous, \$350,000; paints and colors, \$289,000; soap, \$2,000.

American imports of chemicals and allied products from Belgium show rather marked fluctuations of late years for a number of articles. An increased import is noticed in the case of miscellaneous chemicals, Thomas meal, superphosphate and other fertilizers, glue, lubricating oil, perfumery, and soap. It is still more noticeable in the figures for aniline colors, miscellaneous drugs, gum copal, gunpowder, linseed, olein, and vegetable oils, and very pronounced in the case of colors, creosote oil, glycerin, lithopone, nickel, and seeds. Imports of aniline salts and cement are lessening. The decrease is pronounced in the case of bones, miscellaneous chemicals, indigo, and wool grease, and very pronounced for barium sulphate, gelatin, grease, matches, ores, pitch, and starch.

AMERICAN EXPORTS TO BELGIUM.

The United States is exporting an enormous amount of crude calcium acetate, produced by the distillation of American wood. The value in 1910 was \$611,000. It would appear that the manufacture from this material of acetone, the acetates, and possibly acetic acid to some extent could advantageously be carried on at home and the resultant products, even if liquid, be shipped to the foreign markets. Considerable graphite is exported in the raw state, but the shipments in a manufactured form are quite unimportant. Again, great quantities of soap stock are sent to Belgium (value in 1910, \$384,000), while an increasingly large amount of glycerin is received from Belgian ports. This movement is an unnatural one.

In the matter of zinc compounds, lithopone, zinc white, etc., American manufacturers having the raw material directly at hand should be able to compete easily with Belgium, now forced to import her zinc ores. It would appear also as if more of an effort should be made to furnish zinc ore for the Belgian furnaces, as was largely the case in the past. At present America ship thither a comparatively small amount of zinc dross. Practically the entire shipments of American zinc ore, exceeding \$500,000 in value, go to the Netherlands.

The most striking anomaly in this connection is offered by the fertilizer trade. In 1910 the United States shipped to Belgium nearly 66,000 tons of raw phosphate rock, valued at \$447,000. In the same year manufactured fertilizers, chiefly superphosphate, valued at \$467,000, were purchased from Belgium. With the vast deposits of Louisiana sulphur located so near the leading sources of phosphate rock in the United States, it should be possible to transform raw phosphates into superphosphate at rates very decidedly below the cost of production in Belgium plus the cost of freighting twice across the Atlantic.

The exchanges with Belgium represent, in fact, America's general position in the world's fertilizer trade. American shipments of raw phosphates in 1910 had a total value of \$7,455,000. At the same time the total imports of fertilizers, excluding guano and crude phosphates, were valued at \$7,373,000. Germany furnished 63 per cent of this quantity, which comprised nearly equal parts of superphosphate, Thomas meal, and bone meal. There is certainly an extensive field here, worthy of careful attention by those interested in the development of the manufacture of fertilizers on American soil. The domestic supply of sulphur in the free and the combined form is now so ample that it should no longer be economically profitable to send native rock over to Europe to be treated with Belgian or German sulphuric acid. The advantage possessed by the European manufacturer in a relatively low wage rate is becoming constantly less, especially since the introduction of such a variety of labor-saving devices for handling vast masses of finished fertilizers.

The question naturally arises, is it not possible to profit by the example of Belgium, and not only manufacture the entire domestic supply of superphosphate, but also invade more boldly the world's markets for this necessity of modern agriculture? Belgium depends largely upon foreign sources for raw phosphate, and almost entirely upon other countries for the sulphur required to make sulphuric acid. The cost of the latter as a by-product of metallurgical processes is, it

is true, often exceedingly low, but making all allowances for cheap sulphuric acid and cheap labor, there is still a wide margin in favor of the United States with its abundant supplies of raw material.

A still more remarkable exhibit of industrial and commercial aggressiveness is offered by the exports of cement from Belgium. The net exports of cement, after deducting imports, in 1910, had a value of \$3,330,000. In the same year the net exports of cement from the United States amounted to \$1,460,000, most of which went to Canada and Cuba. The enterprise shown by Belgian manufacturers in controlling so largely the international market in this article is worthy of the most careful study, and of imitation.

In the potash industry it is well to note the extreme care now taken in Belgium to rescue the potassium compounds from suint and from beet-sugar ash. Both of these sources deserve thorough attention in countries producing or treating wool on a large scale or cultivating the sugar beet.

Belgium now exports matches to the United States to some extent—\$16,000 in 1911. This export is diminishing of late years, and it would seem that the American match industry is now easily able to meet competition from this direction.

There are a few classes of chemical products the market for which in Belgium is worthy of close study by American manufacturers. Belgium is still largely dependent upon other countries for her supply of varnishes, the net imports in 1910 reaching 933 tons. American exports of varnish to Belgium amounted to \$20,000 in that year. In 1906 they were \$64,000. It is a field in which more effort should be exerted. Belgium purchases from abroad relatively large quantities of perfumes, cosmetics, and pharmaceutical preparations. In all of these branches there is an opportunity for increased effort by American exporters. American medicines are already appreciated, but more could be done in effecting sales by catering closely to the local demand. There is further an opportunity for Louisiana sulphur to compete with the Italian product in meeting the Belgian demand.

In general, Belgium may be regarded from the standpoint of the technical chemist as offering a most instructive example of what can be done in a small country in the healthy development of a large group of closely allied industries. All of the chemical branches dependent to a greater or less extent upon the natural products of the land have been brought to a high state of perfection. In addition, numerous chemical industries utilizing raw materials of foreign origin have been called into existence. In various directions the ability to capture foreign markets for different chemical products has been revealed in an astonishing degree.

NETHERLANDS.

INTRODUCTION.

The dominant note in the evolution of the Netherlands has been essentially commercial. Its manufacturing interests in most branches have been dependent largely upon raw material brought from other regions. The low, flat land, often rescued at great cost from the ocean, is admirably adapted for pastoral and agricultural purposes, but covers scarcely any mineral wealth. Conditions have been exceedingly unfavorable for the development of chemical industries, almost as much so as in Denmark, a country closely resembling the Netherlands in many respects.

Geographically the Netherlands are admirably situated for the exchange of commercial products by rail, river, and sea. There is an exceptionally high degree of thrift, intelligence, and enterprise, and for nearly a century the people have been free from war or military burdens. In addition the extensive colonial dependencies, Java, Sumatra, Guiana, etc., have contributed much to the national wealth. All of these favoring factors have failed to overcome, in any conspicuous degree, the handicap which the Netherlands suffer in the lack of mineral wealth, especially of cheap coal; and yet despite this handicap, in a few chemical industries the land has been able to meet the competition of more favored countries, such as its immediate neighbors, Germany, Belgium, France, and Great Britain. There is further a marked tendency to enlarge the field of chemical industry and to free the country from dependence upon foreign sources of supply. The Dutch Government does all in its power to encourage this tendency.

For the time being the Netherlands are more conspicuous as consumers than as producers of chemical products. The country is also an important center for the distribution of such wares. The widespread commercial relations with the shores of the Baltic and the Mediterranean, and with the Far East, established long before the era of steam, are still actively maintained, and are extended to most other regions. As a result the leading Dutch ports—Amsterdam and Rotterdam—rank high among distributing points. They are worthy of careful study by all manufacturers seeking to enlarge the area of their trade.

The import and export statistics of the Netherlands reflect strongly the effect of this commercial movement, comparable in many ways with that of Hamburg, London, Liverpool, Marseille, and other clearing houses of the world's trade. It is therefore not easy to obtain from the statistical data of the Kingdom an exact measure of the consumption of chemical wares of foreign origin and the exports of goods produced in the country.

HEAVY CHEMICALS.

In the production of the leading acids, bases, and salts the Netherlands are far behind the neighboring countries. The modern organization of these industries on a vast scale in adjacent countries rich in mineral wealth has rendered competition exceedingly difficult.

SULPHURIC, NITRIC, AND HYDROCHLORIC ACIDS.

On account of the cost of transportation conditions favor to some extent the localization of the sulphuric-acid industry. The manufacture was established in Amsterdam in 1849 by G. F. Ketjen & Co., and has steadily developed since then. Until recently nothing has been done to do more than supply the domestic demand. Now there is a growing export to the Dutch colonies and Scandinavia. The firm has two separate factories. In one, sulphuric acid is manufactured by the chamber process. In the other there is a complete plant for producing fuming acid by the contact process. Ketjen & Co. were, in fact, one of the earlier firms to introduce the method and make it a technical success. There is a small factory connected with zinc works at Budal, using the chamber process. The superphosphate works likewise produce the acid needed in their manufacture. Spanish pyrites is used chiefly as raw material, and the importation, serves as an indication of the growth of the industry. The quantity has more than doubled since 1895. The Netherlands are a good market for German sulphuric acid, the most important after Austria-Hungary. The importation from this source amounted in 1911 to 12,200 metric tons. Much of this was undoubtedly sold to other countries. Ketjen & Co. carry on successfully the extraction of ammonia from the sewage of Amsterdam, making use of the Liermur process. This is one of the few instances outside of Paris and some other French cities where the process is made remunerative.

There is a small factory at Nieuwer-Amstel that furnishes much of the nitric acid used in the Kingdom. The consumption is not large, on account of the limited extent of the industries producing high explosives and coal-tar colors. Hydrochloric acid is imported chiefly from Germany, which supplied 2,560 metric tons in 1911.

SODA—POTASH—SALT—SULPHUR.

Fifty years ago the Netherlands possessed soda works that did much to cover the home demand. With the advent of the Solvay process these concerns found it impossible to continue in existence. The five small factories now in operation limit their activity to transforming soda ash into purified soda crystals, and supply exclusively the domestic trade. In 1911, the Netherlands consumed 32,200 metric tons of soda, supplied largely by Belgium, Germany, and the United Kingdom. The German contribution was 5,500 tons. The absence of an organized soda industry causes Holland to depend upon foreign sources not only for hydrochloric acid, but also for bleaching powder and Glauber's salt. The former is secured chiefly from British works, the latter from Germany, which furnished 6,800 tons in 1911.

There are no native sources, and the entire consumption is supplied from abroad. In 1911, Germany shipped to the Netherlands 5,200 metric tons of caustic potash, and 530 tons of the carbonate.

The country is entirely dependent upon foreign sources for salt and sulphur. With the exception of a small amount recovered from gas works, crude sulphur is supplied from Italy. The annual consumption is about 550 tons. There is also an annual consumption of about 1,000 tons of refined sulphur, furnished largely by France. Crude salt comes chiefly from Portugal, with small contingents from Great Britain and Germany. Salt refining is carried on in 35 establishments, employing 500 workmen. The equipment is modern; in fact the first factory effecting the evaporation of saline solutions on the principle of double effect was organized in the Netherlands. There is an annual consumption of 32,000 metric tons for salting fish, and 1,160 tons for cattle and as fertilizer. Chemical works require 8,000 tons, and other industries 1,720 tons. The per capita consumption is 23 pounds. The Netherlands still retain the ancient custom of laying an excise tax on salt for table use. It is not so high as in Italy, amounting to \$12.06 per metric ton. As the annual consumption of fine salt is slightly over 60,000 tons, it furnishes an important item of revenue.

CEMENT—MAGNESIA—THORIUM SALTS.

There is no manufacture of cement in the country, but there is a large and growing consumption. In 1911 it reached 277,000 metric tons. Germany was the chief source, furnishing 120,000 tons, and Belgium occupied the second place. Germany exported, in addition, 36,000 tons to the Dutch colonies.

A somewhat specialized industry has been developed in connection with the production of magnesia. The raw material, a very pure magnesite, is brought from the extensive deposits at Euboea, in Greece. A portion is used in the production of magnesia alba for pharmaceutical purposes, but the bulk is so burned that the carbon dioxide can be collected and compressed to the liquid form. Schmatolla's gas furnace has been found to render good service for this operation, especially when officinal magnesia usta is prepared. Much of the residual magnesia is used in the country itself, for the manufacture of refractory brick and artificial millstones, but there is quite an export to other countries, including the United States. The magnesia alba and magnesia usta are exported almost entirely, over 80 per cent being purchased by Germany and Great Britain. The three leading factories are at Amsterdam, Kampen, and Zoeterwoude.

There is a small factory at Katwijk engaged in the manufacture of thorium nitrate from monazite. The product is used entirely in the country itself for the preparation of incandescent mantles. There are four establishments engaged in this latter branch, the leading ones being at Amsterdam and Rotterdam.

FERTILIZERS.

In a country where so much of the land available for agricultural purposes has been won at such a cost from the domain of the ocean it can readily be imagined that great pains are taken to attain a

maximum degree of productivity. The price of good land is high. The tracts devoted to market gardening about the cities easily command \$400 per acre. Of late years the domestic demand for fertilizers has grown rapidly and there has been a corresponding growth in the number and output of fertilizer factories, as well as in the amount of imported fertilizers.

SUPERPHOSPHATES—GUANO.

There are six establishments devoted to the production of superphosphate and mixed fertilizers, located at Amsterdam, Rotterdam, Capelle, Hoogkerk, Uden, and Zwynndrecht, nearly all accessible to ocean craft. Raw phosphates are brought chiefly from the United States, but also from Africa and the Pacific. Each factory manufactures the sulphuric acid needed for its operations. There are 650 workmen employed in these works and the total output is estimated at 306,000 metric tons. The organization of these works ranks high and the products are able to compete to some extent in the world's markets. In these Dutch works there is an increasing manufacture of ammonium superphosphate. The standard product obtained by mixing ammonium sulphate with ordinary superphosphate contains 7 per cent of nitrogen and 9 per cent of soluble phosphoric acid.

Much of the guano now arriving in the Netherlands contains large amounts of insoluble calcium phosphate and is treated with sulphuric acid in order to secure a soluble product.

AMMONIUM SULPHATE—BONE MEAL.

The manufacture of ammonium sulphate, for use as a fertilizer chiefly, is highly perfected in the Netherlands. Thirty large gas works produce the salt in a commercial form, and the ammonia water of 80 smaller works is collected in a large factory at Weesp and there transformed into sulphate. Increasingly large quantities of ammonium sulphate are now demanded for application in the sugar plantations of the Dutch colonies.

The production of bone meal as a subsidiary product in connection with the manufacture of glue is gaining in importance. In the Dutch works the ordinary procedure is to remove the fatty matter of the bones by extraction with benzine vapor in closed vessels. The bones are then crushed and passed through sieves. The coarser material, containing 4 per cent nitrogen, is used directly as a fertilizer, the phosphoric acid being easily assimilable. The finer material is then extracted with superheated water. The degelatinized residue contains only 0.5 to 1 per cent of nitrogen. Its phosphoric acid (30–35 per cent P_2O_5) is largely in the citrate soluble form, so that it practically has the value of Thomas meal. It is usually sold in this form for use, although in some instances it is treated with sulphuric acid and changed into superphosphate. The various sorts are largely in demand for home use and there is an export of over 3,000 metric tons annually.

IMPORTS OF FERTILIZERS.

While so much is being done to produce artificial fertilizers at home the Netherlands consume, and probably always will consume,

large amounts of fertilizers of foreign origin. The raw material for its superphosphates comes naturally from a distance. The annual consumption of Chile saltpeter has now reached 75,000 metric tons. Dutch agriculture shows an appreciation for cyanamide and for the newly introduced calcium nitrate of Norway. There is a growing consumption of Thomas meal. The purchases from Germany in 1911 reached 131,000 metric tons. Germany in 1911 also shipped to the Netherlands 19,000 tons of ordinary superphosphate, 3,000 tons of other artificial fertilizers, and also 143,000 metric tons of kainite and other Strassfurt crude salts, 1,800 tons of potassium chloride, and 45,000 tons of magnesium-potassium sulphate. Lime salts are also imported to some extent for use as fertilizers.

PIGMENTS AND COLORS.

In earlier days the cultivation of madder was highly developed in the Netherlands, and the preparation of the dyestuff from its root formed an important branch of manufacture. The introduction of artificial alizarin over a third of a century ago caused the disappearance of the madder fields at the same time as in France. Some small factories still continue to import the root from the Orient and to extract the coloring matter.

Woad was also an object of extensive cultivation formerly, but has long since been given up. The importation of natural indigo from Java and from British India was likewise an important feature until recently in the Dutch trade. It has now shrunk to small dimensions. In 1911 the import from Java was valued at \$30,000. Synthetic indigo is largely imported and exported. The total imports of indigo in 1911 were valued at \$727,000; the exports amounted to 940 tons. It is worthy of note that the commercial indigo from the Dutch colony of Java is of a much higher grade than that from Bengal. The average percentage of pure indigo is 70 per cent, as compared with 60 per cent in the Bengal variety.

At present the color industry attempts little in the way of manufacturing coal-tar colors. The chief exception is in the case of a factory at Delft, which takes advantage of the absence of patent protection in the Netherlands and manufactures a variety of the simpler aniline dyes, which are still protected by patents in other lands. The output, valued at about \$200,000 annually, is naturally for domestic consumption. About 100 operatives are employed.

MINERAL PIGMENTS—WHITE LEAD.

The manufacture of mineral pigments is very highly developed, relatively more so than in almost any other European country. There are over 80 factories, employing about 1,200 workmen, now engaged in this industry, as well as in the production of lacs and varnishes. In the majority of these works colors and pigments are prepared ready for use and in large variety.

Varnishes and lacs, especially Japanese lacs, are manufactured in about 35 works, mineral pigments in some 18 works, and colors prepared ready for use in about 28 works. In these larger groups are several specialized factories. There are 8 establishments in which madder is extracted and Turkey-red dyes prepared for use; in 1911

they consumed 29 tons of madder root. Two factories manufacture the simpler aniline dyes. Colors for enameling are made in 1 factory. Copper paints for ships' hulls are a specialty in 5 factories, and ultramarine in 1 factory. Lead and zinc pigments are made the sole products of manufacture in a few works.

From an early date white lead has been an important Dutch product. The process of manufacture in general use throughout the world for the production of this pigment was first perfected in the Netherlands. The Dutch product has always enjoyed a high reputation on account of its covering power and there has been a widespread exportation. The original "Dutch process" consisted in exposing small rolls of sheet lead to the combined action of acetic acid vapors and carbon dioxide. Chambers containing a multitude of small vessels, each with its charge of lead and acetic acid, were surrounded with layers of horse dung or spent tanbark. The latter furnished the carbon dioxide required and maintained the requisite temperature for the reaction. After a lapse of several weeks thick crusts of a basic lead carbonate were formed. These were easily separated from accompanying lead acetate by treatment with water, were ground, and dried.

The entire operation is involved and requires most careful supervision. It is still used in England and Belgium and to a large extent in the United States. In the Netherlands it has been replaced by more direct methods. Thin sheets of lead are suspended on wooden strips in a chamber, into which vapors of acetic acid are driven by slow distillation. Carbon dioxide is admitted simultaneously as the product of the combustion of coke. A temperature of 60° C. is maintained. Such a chamber is charged with 10 tons or more of lead, and the operation lasts for nearly two months. Essentials are the proper proportions between acetic acid and carbon dioxide, the presence of a slight amount of water, and the maintenance of the proper temperature. Under these conditions the product is perfectly white, soft, and greasy to the touch. Otherwise it may be yellowish in appearance and tend toward hardness. The crude product is treated with water in large vats and separated from residual fragments of lead as well as from the soluble lead acetate. It is finely ground when in the moist state and then removed to drying chambers. In the Dutch works elaborate precautions are taken to prevent workmen from inhaling the dust of white lead. Moist sponges protect mouth and nose, and a powerful draft is maintained in the rooms devoted to the manipulation. As a result, cases of lead poisoning are exceedingly rare in connection with this branch of manufacture.

Most of the white lead produced in the Netherlands is now ground with linseed oil and sold in this form for consumption. The demand for white lead in the dry powder diminishes each year, not only in the Netherlands, but throughout Europe.

RED LEAD AND LITHARGE—ZINC WHITE.

Red lead and litharge are manufactured in a single factory. The residues of metallic lead, resulting from the preparation of white lead, serve as raw material for oxidization to the form of litharge. The operation is carried on in a reverberatory furnace, the fused metal being kept in constant agitation. The litharge collected on the

surface is carefully ground and dried in ovens with external heat. A part of the litharge is employed for the clarification of the oils used in making varnish. Most of it serves for the further manufacture of red lead or minium. This is effected by careful heating in a furnace at 300° to 350° C. Small amounts of orange-colored minium are also manufactured by very carefully roasting white lead and the light residues resulting from its washing in the process of its preparation.

The fine quality of Dutch white lead and red lead is largely due to the extreme care taken to employ at the outset the purest form of lead obtainable. The metal is furnished almost entirely from Belgium.

Two factories are devoted to zinc white. The manufacture is based upon the combustion of zinc vapor in a current of heated air. As conducted in the Netherlands, numerous small retorts of refractory material, charged with the metal, are heated in a furnace to the temperature at which distillation begins. The current of hot air passes before the mouths of the retorts and there is an active combustion of the metal. The resultant oxide is carried along by the air current through a series of large chambers constructed of sheet iron, followed by another series of canvas. The light, flocculent oxide is deposited in these chambers, and withdrawn from time to time through openings in the bottom. The oxide collected near the exit of the furnace is of a grayish tinge; the whitest grade is secured in the more distant chambers. Much of the product, as in the case of white lead, is ground with oils. Poppy oil is employed for the finer qualities; linseed oil for the other grades.

LITHOPONE—INK.

A single factory is engaged in the production of this new pigment, for which the demand grows steadily. It consists essentially of a mixture of zinc sulphide and barium sulphate, the latter constituting 70 per cent of the mass. The main reaction consists in bringing together, in the proper proportions, solutions of barium sulphide and zinc sulphate. The resultant precipitate of insoluble zinc sulphide and insoluble barium sulphate is filtered off, dried, calcined in a muffle furnace, moistened, ground, dried in a steam chamber, and reground. The barium sulphide employed is prepared by the reduction of German heavy spar with coal in a reverberatory furnace and extraction with water. The residues from the zinc works, treated with dilute sulphuric acid, furnish the zinc sulphate. The solutions of the latter are usually freed from iron by precipitation with bleaching powder. It has also been found practical to make use of pyrite residues that contain zinc. They are roasted with salt, and the zinc chloride extracted by water is added, with the requisite amount of sodium sulphate, to the barium solution. Despite the numerous operations involved lithopone costs much less than white lead or zinc white. In covering power it is inferior to its rivals, and it tends to assume a grayish tint when exposed to the sun, a tint which disappears, however, with removal from sunlight. There is a growing practice among painters of using lithopone as a ground coat, covering it with a subsequent coat of lead or zinc pigments.

Lithopone is manufactured chiefly for home consumption, but an export trade is beginning. White lead and zinc white are, however, widely exported. The annual export of the former ranges from 8,000 to 9,000 metric tons; of the latter from 10,000 to 12,000 tons. In 1911 Germany imported from the Netherlands 800 tons of lithopone, and exported thither 2,600 tons of zinc white and 1,500 tons of red lead.

There are 12 factories engaged in the manufacture of ink. The output is relatively large, in keeping with the highly developed printing and publishing branches of the Kingdom. In most cases these factories produce also sealing wax and mucilage. One establishment makes a specialty of ink powder for the export trade.

In connection with the subject of colors it is to be noted that there is a considerable consumption in the Netherlands of dyeing materials. Apart from the large textile works, which possess their own dye houses, there are about 60 independent dyeing works employing over 1,200 operatives.

EXPLOSIVES—GAS WORKS.

A single company is engaged in the manufacture of powder and high explosives. It operates two factories near Amsterdam, in one of which gunpowder is made, while the other is devoted to the production of guncotton and nitroglycerin. The bulk of its production is required for the military establishment and for use in the colonies, as the topography of the Netherlands and the limited mineral wealth make few demands for explosives. A few small factories manufacture fireworks and there is a limited exportation, chiefly to Canada and the United States.

The Netherlands was one of the first countries to introduce the use of illuminating gas on an extended scale. It is now manufactured in all cities and towns, and even in many villages. In most cases the works are operated under municipal management. As a rule, the equipment is thoroughly modern and up-to-date. The consumption of gas increases steadily despite the widespread introduction of electricity, which is also usually under municipal control. Much of this increase is due to the growing use of gas for heating and cooking purposes, as well as to the employment of automatic meters for the control of small quantities.

The total number of gas works is 120, and the number of workmen about 8,000. The great majority manufacture both coal gas and carburetted gas, the two often being mixed for general distribution. The amount of carburetted water gas introduced in such mixtures ranges from 10 to 20 per cent. Experience has shown that on account of the simple construction and management of water-gas generators, it is much easier by this combination to provide for changes in consumption, due to the season of the year, and to meet emergencies when accidents happen in the more complex plant needed for coal gas.

The water gas employed for carburetting is usually that produced by the Dellwik-Fleischer system. The construction and operation of the generators are now so highly perfected that fully 75 per cent of the coke used as a charge is transformed into fuel gas. The manipulation is such that periods of gas generation, lasting 5 to 7 minutes, alternate with hot-blast periods of 1 to 2 minutes. On an average, water gas is evolved for 50 minutes during each hour with 51 per cent

of hydrogen and 40 per cent of CO. Benzine is employed for carburetting, usually in the cold.

The price of gas ranges from \$0.59 to \$0.83 per 1,000 cubic feet in the Dutch cities. In the towns rates vary from \$0.71 to \$1.06.

The by-products are carefully utilized. Most of the tar is exported to England or Germany. The latter purchased 2,500 tons in 1911. A part of the product is treated in domestic works. The ammoniacal waters of the smaller gas works are sent to a central factory at Weesp, where ammonium sulphate is manufactured on a large scale. In 30 of the large gas works commercial ammonium sulphate is prepared directly. The output of this group is about 5,000 metric tons annually. The gas works of Arnhem and Haarlem are equipped for the production of liquid ammonia. The annual output is about 900 tons. Much of this is exported to Belgium, but about one-third is sent to Germany. The latter country purchases also some of the crude ammonia water of the Dutch works—760 tons in 1911. In the larger works care is taken to recover the hydrocyanic acid, usually in the form of potassium ferrocyanide. The works at The Hague furnish sodium ferrocyanide.

COAL TAR—COMPRESSED GASES.

There are two large tar works, at Amsterdam and Krimpen, and a few smaller stills. The distillation is confined chiefly to the separation of the hydrocarbons in the cruder forms, benzine, toluene, naphthalene, and anthracene. Carboic acid and its simpler homologues are also isolated. Most of these products are exported. Germany purchases about 1,000 tons annually of the heavier oils.

This industry has been recently introduced. Electrolytic oxygen and hydrogen are now furnished by two factories at Amsterdam and Schiedam. Two other factories, at Amsterdam and Rotterdam, supply liquid carbonic acid. Magnesite is employed largely as a source.

A firm at Utrecht, the *Hollandsche Residugas-Maatschappij*, has recently introduced a relatively simple process for securing technical hydrogen that promises to be of considerable importance, as the demand for this gas in connection with aeronautics grows rapidly. The fundamental idea is the decomposition of hydrocarbons at an elevated temperature into carbon and free hydrogen. It has been worked out in Germany in various directions, the most noteworthy being the transformation of the methane in ordinary illuminating gas into hydrogen and carbon. At Utrecht use is made of the tar collected in connection with the manufacture of carburetted water gas in Holland, and also of petroleum residues from Galicia and Texas. These matters are introduced into iron generators filled with glowing coke, when the decomposition takes place instantly.

The sequence of operations is somewhat more complicated than that involved in the production of water gas, but in practice it works very simply. By a hot-air blast from the bottom of the generator the coke is raised to a high temperature. The hydrocarbon residues are then sprinkled on the top of the charge of coke for two to three minutes. The generator is filled with hydrogen, and this is expelled to a reservoir by means of a current of steam. The hot-air blast is renewed, etc. A gas containing 96 per cent of hydrogen is secured by this means. By passing it through a cylinder of coke at a still

higher temperature a product containing 98.4 per cent of hydrogen can be prepared. Portable generators have been constructed, allowing the easy generation of the gas at any point; they promise to be of great convenience for ballooning. The 96 per cent gas as produced at Utrecht costs \$0.35 per 1,000 cubic feet, or about \$0.06 per pound.

MATCHES—CELLULOSE—PAPER.

The manufacture of matches was started in 1870 in the region about Eindhoven, in southeast Netherlands. It is a section where poplar is abundant and serves for the production of the wooden shoes so characteristic of the country. The wood proved to be well adapted for the purpose, and the new industry gradually extended north. There was overproduction, and in 1880 several competing companies combined and concentrated their manufacture in a single large factory at Eindhoven, which employs 350 operatives and produces about 400,000 boxes daily. There are also two other factories at Breda, with a total force of 300 workmen. In 1901 the Netherlands forbade the use of white phosphorus in the manufacture of matches. The industry is now confined exclusively to the production of the safety matches manufactured after the style of the Swedish article. The Dutch manufacturers have followed the example of their Swedish competitors and now make use of Russian aspen instead of poplar. Red phosphorus is purchased in England and Germany. The latter country supplies also potassium chlorate. While covering most of the home demand, there is a large and growing exportation, especially to the Orient. In 1908 this exportation exceeded 84,000,000 boxes.

The cellulose industry is somewhat limited. Of the four factories, one makes mechanical cellulose and two chemical cellulose, while the fourth employs straw. There is a considerable importation from Scandinavia and Germany, the latter furnishing about 7,000 tons annually.

The manufacture of paper attained a high development in the Netherlands at a very early date, the first paper mill dating from 1606. It still remains an important industry, and various grades and marks are well known in international trade. It was in Holland that the first mechanical device for treating rags and other paper stock with water and transforming them into pulp was perfected and put in operation. The universal use to-day of the "Hollander" in all paper works is a tribute to Dutch inventive ability in this field. At present there are 35 paper mills in existence, employing 2,700 operatives. The majority are in the Province of Guelder, on both sides of the Rhine. The great bulk of the paper produced is machine-made, but in a few mills handmade linen paper is manufactured for the special demands of artists and bibliophiles. The production of so-called parchment paper through the action of sulphuric acid on ordinary paper has become an important branch of recent years. Straw is used to only a slight extent in the manufacture of paper, rags and cellulose being the chief raw materials. In fact, the collection and sorting of rags for the needs of paper mills has assumed large dimensions in the Netherlands, and paper stock has become an important item of export. Printing paper for newspapers is the leading product of the mills and is made exclusively from mechan-

ically ground wood pulp. Chemically prepared cellulose is employed for book paper and much of the writing paper.

The manufacture of cardboard and pasteboard from straw has assumed large dimensions during the past 30 years. There are now 20 factories, employing 1,500 operatives and producing 700 tons daily. Much of the output is exported, largely to England, Belgium, South America, and the Dutch colonies. The total annual export of paper and pasteboard exceeds in value \$5,000,000. Imports of paper and pasteboard, largely from Germany and Belgium, reach annually \$3,400,000.

One of the chief causes for the prominence of the paper industry in the Netherlands is the high perfection of typographic work in the country. There are now in the kingdom over 500 printing offices of some size, employing 14,000 operatives.

GLUE—CAOUTCHOUC.

The manufacture of glue is fairly well developed. The leading factories are at Utrecht, Delft, and Dongen. Bones form almost exclusively the raw material, the supply of hide and leather refuse in the Netherlands being exceedingly limited. The works at Delft make a specialty of high-grade gelatin. The glue and gelatin produced, as well as the bone fat, are used chiefly at home. Bone meal and animal bone charcoal are exported to a considerable extent.

The manufacture of articles from caoutchouc, gutta-percha, and balata has become of importance in the Netherlands, largely as the result of the extensive cultivation of rubber trees and plants in the Dutch East Indies and in Dutch Guiana. Amsterdam is the chief center of the commerce in the crude product of the plantations, while Rotterdam furnishes a similar market for the material gathered in forests. The balata of Surinam is an important item in the latter category. There are four factories devoted to the manufacture of rubber articles; all of them include articles in ebonite. An establishment at Haarlem has taken up the manufacture of rubber paving blocks.

TANNING.

This industry was of considerable importance in earlier days and is still carried on extensively. Its prominence is due largely to the heavy trade in hides and skins of the Dutch ports. A special feature of this trade is the import of buffalo hides from the East Indies. In 1909 there was an import of 577,000 hides of this category. The introduction of modern methods in tanning has led to a notable reduction in the number of tanneries. Forty years ago they numbered 1,000. Now there are 460, with 2,500 workmen. The majority are located in the south, in the Province of Brabant. A few establishments still follow the old methods and make use of oak bark. Most of the tanneries employ quebracho and other extracts, and chrome tanning becomes more and more general. There is a very large trade in tanning materials in Rotterdam and Amsterdam. There is one factory in the Netherlands for the manufacture of genuine parchment.

STARCH—DEXTRIN—GLUCOSE.

The manufacture of starch in the Netherlands dates back at least two centuries. (The use of the material to stiffen lace ruffs and articles of apparel was a Flemish invention of 1525.) Early in the nineteenth century there were 30 factories in existence. Rice and wheat were originally employed as sources, but they have now been superseded largely by American corn. There are now 13 factories, employing 400 operatives, occupied in producing corn starch, as well as small quantities of rice starch and wheat starch. The gluten from the last mentioned is employed in the preparation of gluten bread, while the residues from corn starch serve as a cattle food. There is a limited export of corn starch, chiefly to England. In 1840 the first potato-starch factory was erected. The manufacture has grown steadily since then and has proved of great value in stimulating potato culture in certain sections. Much boggy territory, especially about Groningen, was found to be particularly well adapted for this culture after the removal of the peat deposits.

Large tracts of former bogs are now under thorough cultivation and have assumed at the same time a semi-industrial character. Of the 42 factories devoted to potato starch, several are operated as co-operative undertakings, as is so frequently the case with sugar works and cheese factories. Over 70,000 acres are devoted to potato growing in order to supply the demand. The annual crop is about 730,000 metric tons and its average value \$4,000,000. Of the total number of works, 30 produce dry starch alone, 2 furnish also starch in the moist form, 6 have added the manufacture of dextrin, and 6 more transform starch into glucose. While the glucose is used almost exclusively to meet the home demand, the bulk of the potato starch and the dextrin is exported. In 1911 this export amounted to 88,000 metric tons. The quantity of dextrin included in this figure is estimated at 5,000 tons. The export was chiefly to Germany and Belgium, but included also considerable amounts for Great Britain and Italy. Against this export figure is to be reckoned an import of 27,000 tons of potato starch, coming almost entirely from Germany. The exports and imports of corn starch balance each other very nearly. About 15 per cent of the potato starch produced is used in the Netherlands itself, chiefly in its textile works. It has been estimated that the production of potato starch in the Netherlands has more than doubled since the beginning of the present century.

The manufacture of glucose began about 1880. At present, in addition to the six starch factories already mentioned, there are five other establishments devoted exclusively to the transformation of starch into glucose. Apart from the growing tendency to employ glucose in the preparation of confectionery, jellies, etc., there is a marked use of the material in breweries and in textile works. A considerable amount of solid glucose is changed into caramel by heating to 220° C.; in this form it is employed to color vinegar, beer, wine, and various sauces, etc.

The starch industry, with its dependent branches, is regarded in the Netherlands as of prime importance, being the chief chemical manufacture utilizing so largely a domestic raw material.

OILS AND FATS.

The extraction of oils assumed prominence at an early date in the Netherlands. Hundreds of windmills were built so that they could be employed at will for grinding grain or expressing oils. The modern oil mills make use of steam and are usually well equipped with hydraulic presses, etc., although not many are of large size. A few, while operating with steam power, still use instead of presses huge old-fashioned millstones. They number in all 220, and employ 2,835 workmen. The materials used are linseed, rapeseed, sesame, peanuts, and the soya bean. The first two are produced to quite an extent in the country itself, while the three others are imported.

About 25,000 acres are devoted to flax culture. The annual production of linseed is estimated at 220,000 bushels. The Netherlands formerly led in the production of rapeseed. The culture has steadily retrograded with the decreased use of colza oil for the purpose of illumination. The annual crop of rapeseed at present is about 300,000 bushels. Peanuts are brought from the African coast and American countries and from Java. The latter supplies much of the sesame, and the soya bean comes exclusively from Manchuria.

TRADE IN SEEDS, OILS, AND OIL CAKE.

Apart from the requirements of the domestic oil mills the trade in oleaginous seeds has long been a pronounced feature in the Netherlands. In 1911 the movement was as follows, in metric tons: Imports—linseed, 171,000; peanuts, 48,000; rapeseed, 48,000; soya beans, 26,000; exports—linseed, 43,000; peanuts, 13,000; rapeseed, 16,000; soya beans, 12,000. The imports of rapeseed come almost exclusively from Belgium, and those of linseed come largely from Belgium, but also from Argentina, Russia, and British India.

Of other oleaginous matters mention may be made of the castor-oil bean, the annual imports of which amount to 800 tons, and of palm nuts, imported to the extent of 32,000 tons and exported to the extent of 29,000 tons. The commerce in copra has assumed large dimensions, about one-fifth of the European consumption being landed in the ports of Holland. The average annual importation is 62,000 tons, of which about 6,000 tons are consumed in the manufacture of candles, soap, etc. The remainder is sold largely to Germany and Belgium. Java and the Dutch colonial possessions in the east are now taking the lead in meeting the world's demand for copra. In 1910 they furnished 161,000 metric tons.

The commerce in expressed oils shows likewise an important trade movement apart from the products of the country. In 1911 it was as follows:

Oils.	Imports.	Exports.	Oils.	Imports.	Exports.
	<i>Metric tons.</i>	<i>Metric tons.</i>		<i>Metric tons.</i>	<i>Metric tons.</i>
Coconut.....	12,820	4,140	Poppy.....	25	.....
Cottonseed.....	12,040	150	Rapeseed.....	1,350	1,770
Linseed.....	90	32,970	Sesame.....	1,320	520
Olive.....	140	80	Soya bean.....	6,330	30
Palm.....	22,900	7,860	Other.....	510	220
Peanut.....	590	8,120			

The large export of linseed oil goes chiefly to Great Britain, Austria, Belgium, and Germany. That of peanut oil is taken mostly by Great Britain. The United States furnishes the cottonseed oil. Oil of sesame is supplied by Germany, poppy oil by France, soya-bean oil by Great Britain and Belgium, and palm oil by Great Britain. Oil of sesame is now largely employed in the manufacture of margarine.

The oil cake produced by the oil mills is consumed chiefly in the country itself as cattle food. The only exception is in the case of peanut cake, the export of which reaches 30,000 tons annually. A large establishment in Delft makes a specialty of the preparation of fine salad oil from peanuts, and of peanut flour. In addition to the domestic production, the Netherlands consume a large amount of imported oil cake. These imports in 1911 were as follows, in metric tons: Cotton seed, 26,200; linseed, 198,300; peanut, 3,400; rapeseed, 9,100; other, 54,700. The United States supplies nearly all of the cottonseed meal and one-half of the linseed cake.

ANIMAL OILS—MARGARIN.

There is an annual consumption of 5,000 tons of train oil, furnished chiefly by Norway. The net import of lard is 12,000 tons, coming mostly from the United States. That of tallow reaches 36,000 tons, and is supplied by Great Britain, Belgium, and the United States. Oleomargarin imports for consumption reached 24,000 tons in 1911, furnished almost entirely by the United States.

The first factory for the manufacture of artificial butter by Mège-Mouriès' process was established in the Netherlands in 1871. Since then the industry has extended rapidly, as was to be expected in a country where the dairy interests are highly developed. There are now 20 factories, employing 1,900 operatives. Several firms engaged in this manufacture have branch factories in Belgium and Germany. The domestic consumption is growing steadily, and there was an export in 1911 of 46,000 metric tons. Great Britain is the chief purchaser. Small amounts go to Scandinavia and oriental lands. Local law guards very closely the correct branding of the product. There is an increasing demand in the Netherlands for imitation butters made from copra and other vegetable fats.

CANDLES AND SOAP.

The manufacture of candles in the Netherlands began about 60 years ago, and the products possess a well-earned reputation in international trade. The industry is highly concentrated, there being but two factories. One at Schiedam employs 550 operatives, and the second at Gouda has a force of 600. The imports of palm oil are used chiefly in this industry. The bulk of the production is exported, as the domestic demand is limited. In 1911 the exports reached 3,000 metric tons. A considerable portion of the stearin obtained by the decomposition of fats is not molded into candles, but is exported in solid blocks to those countries levying high duties on candles. The manufacture of candles, composed of a mixture of stearin and paraffin, has been introduced recently to compete in the Far East with the paraffin candles now made by the petroleum companies of Burma.

In a few small establishments wax candles, and tallow candles for ecclesiastical use, are still manufactured. There is a net annual importation of 1,800 tons of wax.

There are 45 soap works employing 850 operatives. Most are comparatively small. In 10 large works there is a modern equipment and recovery of glycerin. Most of the product is absorbed by the home market, but there is a growing export of fancy soap, powdered soap, and soap for textile purposes to the Dutch colonies and other oriental countries. There was an excise duty in the Netherlands on soap until 1893.

GLYCERIN—OLEIN—STEARIN PITCH.

The candle factories and some of the soap factories recover the glycerin liberated in the process of saponification. Much of this is refined in a factory for the purpose, located at Naarden, and exported for use in manufacturing nitroglycerin. The annual export exceeds 600 tons. It is shipped chiefly to South Africa and to England. The oleic acid obtained in the manufacture of candles and stearin is used to some extent in local soap works in the production of cheap grades of hard soap. There is an annual export of over 3,000 metric tons of olein, taken chiefly by Belgium. The residue from candle works, known as stearin pitch, is carefully collected in the Dutch factories and employed in the preparation of a substitute for gutta-percha, which now finds increasing use for protecting exposed metallic surfaces, and especially for coating electric wires and cables.

The pitch is mixed with one-sixth of its weight of ceresin or ozokerite and fused at 110° C. to a homogeneous liquid. Powdered picric acid (about 3 per cent of the weight of the liquid) is slowly added, under constant agitation. The agitation is continued while the temperature is raised to 125° C., and maintained there for some time. Vegetable fibers in a finely divided form are next added, the temperature is raised to 140° , and the liquid mass is poured into molds of the desired form. This imitation gutta-percha resists the attack of ordinary acids, and is reported to render good service in isolating electrical connections.

PETROLEUM.

The Netherlands depend for the supply of refined petroleum very largely upon the United States. There is, however, a growing importation of crude petroleum, chiefly from the Dutch colonies, which is refined at Rotterdam. The refinery is well equipped and supplies some 15 different grades of oil and gasoline. About one-half of the gasoline required by automobiles in the Netherlands comes from this factory. A large amount of Dutch capital has been invested in the petroleum trade, and competes directly with American petroleum interests in international commerce. It controls the production in the Dutch East Indies, where the annual output of crude oil exceeds 2,000,000 metric tons. This oil is peculiarly rich in the lighter hydrocarbons, and gasoline from this source competes closely with American gasoline in many markets. There is a single establishment at Amsterdam occupied with the preparation of paraffin. It uses a

crude material brought from the Dutch colonies, and the annual output is over 1,000 tons. It is largely used in the candle factories, but there is a slight export. Lubricating oils are largely imported. The amount purchased in 1911 from abroad reached 13,600 metric tons. The United States furnished 5,700 tons, and Belgium 5,000 tons.

The Rotterdam refinery has put upon the market a substitute for turpentine oil that consists of certain aromatic hydrocarbons occurring in unusual abundance in the crude petroleum of Borneo and easily separated by fractionation. The Netherlands import over 300 tons annually of turpentine from France and Belgium. Much of it is exported to Germany.

QUININE—ACETIC ACID.

Cinchona bark forms one of the most important products of the Dutch colonies, and Amsterdam is the chief market for its purchase and distribution. The imports in 1911 reached 8,070 metric tons, of which 5,440 tons were reexported. This import is the equivalent of nearly 500 tons of sulphate of quinine, and is about 20 times greater than the receipts of bark at London. There are two factories for the manufacture of sulphate of quinine, one at Amsterdam and the other at Maarsse. The manufacture of other products is not so highly specialized as in the American and German works. Numerous American preparations are encountered in the Dutch pharmacies. Cocaine is manufactured on a small scale at Amsterdam.

There are two factories engaged in the production of acetic acid, one of which manufactures also lead acetate. Imported calcium acetate is used as raw material. Several small establishments employ the purified acid to prepare "essence of vinegar" for household use. It is practically an 80 per cent acid, carefully freed from empyreumatic odors, and rendered fragrant by digestion with fennel, caraway, and other herbs. This essence is steadily displacing the ordinary vinegar, the consumption of which decreased nearly 50 per cent from 1903 to 1908. The 59 vinegar factories in the country employ the rapid method of oxidation, based upon the use in fermentation casks of weak alcohol, with malt or other nitrogenous food for the acetic bacteria.

MISCELLANEOUS ORGANIC COMPOUNDS.

There are small factories engaged in the manufacture of chloroform, ether, and ethyl chloride, all for the domestic market. Over a dozen establishments produce pharmaceutical preparations, some of them making a specialty of medicines in the tablet form. The annual consumption of crude opium in these factories is about 4,500 pounds. Several firms furnish dentifrices, antiseptic bandages, artificial mineral waters, and salts for the same. Seven establishments supply rennet and coloring matter for dairy purposes and operate on a large scale. Several of the specialties are articles of export, more particularly to the East Indies, Japan, and South-Africa.

There are several perfume factories producing chiefly eau de cologne. The manufacture of artificial musk (trinitroisobutylene) has been established at Melik-Herkenbosch; but vanillin, ionon, and the other new synthetic perfumes are all purchased from Germany. Most volatile oils are likewise imported, but there is a rapidly grow-

ing industry in the production of fruit essences, based upon the use of native fruits. In three factories harness oil of a high grade is manufactured.

SUGAR—ALCOHOL.

The beet-root sugar industry is firmly established in the Netherlands. About 135,000 acres are devoted to the culture of the plant and the sugar factories number 27, with a force of 7,500 workmen. About one-sixth of the crop goes to the Belgian works for extraction. The annual production of raw sugar exceeds 200,000 metric tons. The refineries number 11, but more than half of the refining is done in two large establishments at Amsterdam that employ 1,150 operatives. Cane sugar is now no longer brought to the Dutch refineries, but there is an annual import of about 15,000 tons of raw beet sugar. The domestic consumption of sugar is over 80,000 metric tons, which means a per capita consumption of 31.5 pounds. The Netherlands still levy an excise duty on sugar of \$4.93 per 100 pounds.

The export of refined sugar goes almost entirely to Great Britain. It averages 100,000 metric tons annually. Milk sugar is produced in three factories.

For centuries the Netherlands have been known for the extent of their distilling industries. The number of establishments is even now very great, and the annual export of distilled liquors exceeds 8,600,000 gallons. The per capita consumption of spirituous liquors (50 per cent alcohol) is 1.85 gallons. The large distilleries manufacturing alcohol number 126. Of a total annual production of over 19,000,000 gallons (50 per cent alcohol), 7,600,000 gallons are produced from beet-root molasses and the remainder from grain. A considerable amount is denatured and employed for heating purposes. The greater part is used in the manufacture of gin, bitters, etc. The manufacture of yeast has assumed large dimensions in these distilleries. There is an average annual export of about 5,700 metric tons. Belgium purchases 250 tons. Most of the remainder goes to Great Britain.

FUELS.

The Netherlands depend almost entirely on foreign sources for the coal supply. There is, however, a tract in the southeastern part of the Kingdom, in the Province of Limburg, where coal measures are fairly abundant. Conditions are not very favorable for mining, and the coal is of somewhat inferior grade. The area of territory known to contain coal deposits of distinct value is over 200 square miles and systematic exploitation is adding new tracts. There are at present 6 mines in operation, 2 of which are owned by the State. The number of miners is 6,450 and the annual output is about 1,200,000 metric tons. Of this amount 70 per cent is exported across the adjacent frontier to German industrial centers. The average price per metric ton is \$2.73. The exploitation on a fairly large scale began about 15 years ago and has multiplied tenfold since then. Nearly one-half of the known coal territory is in the control of private companies. Recent legislation reserves to the State the right of exploiting newly discovered coal lands, and also the privilege of expropriating the concessions now held by private companies.

The net imports of coal into the Netherlands amounted in 1911 to 7,010,000 metric tons. Germany furnishes four-fifths of this quantity and Great Britain most of the remainder.

The extraction of peat as a fuel is highly perfected, more so, probably, than in any other country. The annual value of peat fuel is about \$3,200,000. About 1,000 acres of peat bog are annually transformed into arable land. The special preparation of light, porous peat gathered from the upper layers of bogs has become an industry of importance in recent years. It replaces straw for stable litter as well as for packing purposes and protecting bulb plantations. The exportation of peat in this form has become a large item, absorbing nine-tenths of the annual production.

METALLURGY.

The soil of the Netherlands conceals little in the way of metallic ores. In the east and southeast there are a few scattered veins of iron ore of a relatively inferior quality. They have been worked intermittently, the annual output sometimes reaching 3,000 tons. Smelting is carried on in 4 blast furnaces, but ore is frequently taken across the frontier to be reduced in Westphalian furnaces.

The metallurgy of zinc is more highly developed. Zinc blende, partly from American mines, is brought in large quantities to a large establishment at Budel, where it is smelted. The brand of these works, the Nouvelle Montagne, is well known. The concern employs about 800 workmen, and furnishes the raw material for the extensive manufacture of zinc pigments, as well as a considerable amount of metal for exportation. In 1911 the Netherlands imported 49,000 metric tons of raw zinc and 8,700 tons of refined zinc, almost all from Belgium. The export was 68,000 tons of raw zinc and 2,000 tons of refined.

The metal industries are fairly well developed and show great diversity. The imports of iron and steel, raw and worked, amounted to 1,347,000 metric tons in 1911. The exports were 884,000 tons. The construction of cables, anchors, and other naval material is especially important.

The annual consumption of raw copper supplied by the United States is about 10,000 metric tons. The Netherlands are the center of an extensive trade in this metal, over 100,000 tons being purchased for reexportation. There are a number of establishments for the production of copper castings, wire, and rod, and for the manufacture of a large variety of objects from the metal.

There are large works for rolling sheet zinc and sheet lead and for producing lead pipe. Tin foil is also made on a large scale. The annual consumption of raw lead is about 10,000 metric tons. Much is used in the manufacture of white lead, and there is an export of about 2,500 tons of lead pipe and sheet. The annual consumption of raw tin is about 3,000 metric tons.

It will be seen from this review that the Netherlands, despite the poverty of natural resources, have developed a wide variety of chemical industries that hold their own in international commerce. This is chiefly the result of native thrift and ingenuity. The protection afforded manufactured chemicals never exceeds 5 per cent. Raw materials enter free of duty.

STATISTICS OF THE TRADE IN CHEMICALS.

The market for chemicals, caused by the diversified general industries of the land, is relatively large. The import of chemicals, not specially designated, had in 1911 a value of \$5,269,000. The exports were \$4,000,000. Of the imports 67 per cent came from Germany, 7.5 per cent from Great Britain, and 5 per cent from Belgium. The exports were largely to Great Britain and Germany.

Apart from quinine, opium, seeds, oils, etc., the imports in 1911 of miscellaneous drugs was valued at \$4,820,000. The Dutch colonies furnished 45 per cent and Germany 23.5 per cent of this amount. Exports reached \$3,710,000. Much went to Great Britain and Germany. The United States purchased to the extent of \$600,000. As a purchasing country for chemicals and allied products the Netherlands owes its importance therefore more to its commercial relations in international trade than to the home consumption.

In 1910 Belgium exported to its neighbor the following merchandise:

Articles.	Metric tons.	Articles.	Metric tons.
Alcohol:		Metals—Continued.	
Amylic	142	Lead	4,355
Methyl—		Nickel	56
Crude	34	Tin	157
Refined	4	Zinc	13,686
Alcoholic preparations	34	Molasses	13,600
Bones and horns	2,356	Paper	4,520
Candles	473	Perfumes	4
Caoutchouc	815	Petroleum	41,624
Cellulose	5,277	Resins and bitumen	16,426
Cement	130,000	Salt	781
Chemicals, miscellaneous	72,954	Soap:	
Colors:		Soft	11
Miscellaneous	3,787	Hard	12
Dyewoods	647	Toilet	31
Madder	.5	Soda ash	4,320
Fuel:		Sodium sulphate	2,886
Coal	299,000	Starch	1,537
Coke	54,490	Sugar	24,080
Briquets	27,000	Sulphur	1,227
Charcoal	750	Tanning material	4,096
Drugs, miscellaneous	2,785	Varnish	50
Fats:		Vegetable oils, seeds, etc.:	
Miscellaneous	5,771	Linseed	64,349
Lard	200	Peanuts	1,631
Oleomargarin	44	Poppy seed	58
Fertilizers:		Rapeseed	29,946
Miscellaneous	10,690	Sesame	2,650
Ammonium sulphate	1,152	Copra	29
Chile saltpeter	32,000	Castor oil	138
Guano	5,125	Coconut oil	4,747
Superphosphate	54,900	Cottonseed oil	209
Thomas meal	23,750	Linseed oil	65
Glue	128	Maize oil	29
Gunpowder	58	Olive oil	22
Lime	160,000	Palm oil	422
Matches	207	Peanut oil	280
Metals:		Rapeseed oil	143
Iron ore and slag	20,240	Sesame oil	448
Aluminum	9	Other oils	1,069
Copper	275	Oil cake	12,250
Iron and steel, pig, rod, etc.	3,635	Wax	12
Galvanized iron	286	Yeast	386

The following table shows the imports of various chemical products from Germany during 1911:

Articles.	Metric tons.	Articles.	Metric tons.
Acids:		Lime.....	12,280
Acetic.....	376	Licorice paste.....	92
Hydrochloric.....	2,560	Mantles, incandescent.....	38
Sulphuric.....	12,222	Mercury.....	4
Albumen.....	17	Metals:	
Alizarin:		Copper.....	105
Paste.....	212	Lead.....	3,176
Dyes.....	101	Tin.....	449
Alkaloids.....	1.3	Zinc.....	649
Aluminum sulphate.....	2,625	Methyl alcohol.....	236
Alums.....	186	Mineral-water salts.....	34
Aniline colors.....	1,035	Oil seeds:	
Barytes.....	15,795	Linseed.....	1,414
Bauxite.....	587	Sesame and other.....	2
Blackening and shoe polish.....	521	Oils:	
Borax:		Lubricating.....	2,992
Crude.....	62	Resin.....	57
Refined.....	356	Gasoline.....	560
Calcium acetate.....	6	Coconut.....	2,119
Calcium carbide.....	615	Palm.....	374
Caoutchouc.....	62	Peanut.....	260
Carbolic acid, liquid.....	993	Poppy.....	1,343
Cement.....	119,981	Rapeseed.....	1,585
Cement materials, tufa, etc.....	21,027	Oil cake.....	61,325
Chemical foods.....	22	Olein.....	127
Chemicals miscellaneous.....	1,230	Ores and slags:	
Colors and pigments:		Lead.....	521
Chrome colors.....	410	Zinc.....	4,169
Lithopone.....	1,160	Slags.....	4,214
Ochers.....	2,035	Perfumes:	
Red lead.....	883	Synthetic.....	16
Ultramarine.....	460	Eau de Cologne.....	90
White lead.....	830	Pharmaceutical preparations.....	108
Zinc white.....	390	Pitch.....	10,649
Prepared colors.....	262	Potash salts:	
Copperas.....	600	Carbonate.....	535
Drugs, miscellaneous.....	105	Caustic.....	5,185
Dynamite.....	151	Chloride.....	1,873
Fats:		Iodide.....	8.8
Lard.....	700	Nitrate.....	876
Tallow.....	157	Sulphate.....	1,858
Fertilizers:		Potassium magnesium sulphate.....	44,786
Ammonium sulphate.....	9,339	Salt, crude.....	37,253
Animal refuse.....	5,383	Soap:	
Bone meal.....	1,465	Hard.....	198
Chile salt-peter.....	2,403	Soft.....	499
Guano—		Toilet.....	169
Natural.....	346	Pomades.....	269
Artificial.....	1,231	Soda ash:	
Potash salts, Stassfurt.....	143,171	Crude.....	188
Superphosphates.....	13,954	Refined.....	5,351
Thomas meal.....	131,479	Sodium sulphate.....	6,805
Fruit essences.....	1.2	Starch:	
Fuel:		Corn.....	696
Bituminous coal.....	5,950,581	Rice.....	510
Coal briquets.....	218,555	Sugar:	
Coke.....	228,228	Beet.....	35,020
Lignite.....	11,109	Milk.....	110
Lignite briquets.....	216,743	Tanning extracts.....	147
Charcoal.....	3,943	Tar:	
Peat.....	32,378	Wood.....	827
Gases, liquefied.....	177	Coal.....	66,221
Glue.....	646	Heavy oils, nitrobenzene, anthro-	
Glycerin:		quinone, etc.....	117
Crude.....	1,182	Turpentine and resin.....	281
Refined.....	347	Varnish.....	489
Graphite.....	6	Water glass.....	4,142
Gunpowder.....	45	Witherite.....	306
Gypsum.....	6,064	Wood pulp, chemical.....	6,801
Indigo.....	579	Zinc chloride.....	326
Ink, printers'.....	321		

It will be seen from the table that the Netherlands offer an important market for manufactured chemicals and for the raw materials of chemical industry. In addition to the quantities given, Germany ships a considerable amount of manufactured chemicals, especially dyestuffs and organic compounds, to Java and the other Dutch colonies in the East Indies. The demand in these colonies is steadily growing and is becoming an important factor in the chemical trade. For example, in 1911 they purchased from Germany 197 tons of aniline dyes, 454 tons of alizarin, 686 tons of synthetic indigo, 20,682 tons of ammonium sulphate, 241 tons of potassium cyanide, etc.

TRADE WITH THE UNITED STATES.

The extent to which the United States participates in the Dutch market may be determined from the following table, which shows the Dutch imports of American chemicals and allied products for the fiscal year 1910:

Articles.	Value.	Articles.	Value.
Asphaltum.....	\$24, 700	Oils—Continued.	
Blacking.....	4, 000	Mineral—	
Bones, horn, etc.....	2, 300	Lubricating.....	\$1, 153, 000
Chemicals:		Naphtha.....	303, 200
Calcium acetate.....	231, 300	Petroleum.....	6, 042, 000
Dyes.....	14, 400	Residues.....	38, 200
Patent medicines.....	8, 300	Expressed—	
Roots, herbs, etc.....	18, 300	Corn.....	21, 100
Sulphur.....	22, 800	Cottonseed.....	3, 674, 000
Tanning extracts.....	2, 000	Other.....	5, 800
Wood alcohol.....	70, 800	Essential.....	1, 800
Miscellaneous.....	45, 000	Paints, pigments, etc.:	
Copper.....	24, 066, 000	Lampblack.....	26, 900
Fertilizers, phosphate rock.....	950, 800	Zinc oxide.....	66, 900
Glue.....	900	Other.....	26, 300
Glucose.....	1, 800	Paper.....	51, 400
Grape sugar.....	3, 700	Paper stock.....	14, 400
Graphite.....	600	Paraffin.....	243, 000
Grease.....	379, 900	Perfumery, cosmetics.....	3, 900
Ink.....	1, 000	Seeds:	
Lead.....	1, 100	Cotton seed.....	52, 100
Nickel.....	2, 370, 000	Linseed.....	49, 500
Peanuts.....	5, 600	Other.....	10, 600
Rosin.....	837, 300	Soaps, toilet.....	4, 000
Oil cake:		Starch.....	149, 400
Cottonseed.....	783, 000	Tar, turpentine, pitch.....	7, 500
Corn.....	119, 000	Turpentine, spirits.....	1, 267, 000
Linseed.....	4, 073, 000	Varnishes.....	16, 900
Oils:		Zinc ore.....	534, 000
Oleo.....	5, 526, 000		
Other animal.....	79, 300		

It is worthy of note that the Netherlands are America's chief market for copper, nickel, oleo oil, and cottonseed oil. In the case of several other products the country is outranked by only one to three countries, as follows: Linseed oil cake, by Belgium; spirits of turpentine, by Germany; phosphate rock, by Germany, Denmark, and the United Kingdom; cottonseed oil cake, by Germany, Denmark, and the United Kingdom; rosin and petroleum, by Germany and France.

In American imports into the Netherlands there has been a very rapid increase during the past few years in the case of nickel, wood alcohol, and calcium acetate and a more moderate increase in the case of naval stores, naphtha, roots, herbs, etc.

Sales of glucose, lead, zinc oxide, and peanuts are steadily decreasing; in the case of the last mentioned the falling off is very marked.

Exports of chemicals and allied products from the Netherlands to the United States are shown in the following table:

Articles.	Value.	Articles.	Value.
Chemicals:			
Ammonium sulphate.....	\$11,800	Glue.....	\$1,000
Aniline salts.....	12,700	Mantles, incandescent.....	600
Bleaching powder.....	2,000	Matches.....	2,300
Cinchona bark.....	221,600	Oils:	
Coal tar—		Cocoa butter.....	479,000
Colors.....	16,500	Coconut oil.....	700
Preparations.....	2,500	Peanut oil.....	227,100
Products, miscellaneous.....	7,000	Rapeseed oil.....	4,000
Dyewood extracts.....	600	Other expressed oils.....	103,700
Fusel oil.....	1,200	Essential oils.....	44,500
Gelatin.....	3,700	Oleostearin.....	410,900
Glycerin.....	203,000	Paints, pigments, and colors.....	52,500
Gums—		Paper.....	76,500
Copal, dammar, etc.....	20,300	Paper stock.....	256,100
Other.....	2,500	Seeds, oleaginous.....	429,500
Magnesia.....	35,300	Soap.....	1,100
Potash, caustic.....	500	Starch.....	30,500
Potassium carbonate.....	1,000	Tin.....	261,200
Quinine, sulphate, and salts.....	91,000	Wax.....	6,600
Sodium salts.....	2,500	Wood pulp, chemical.....	4,400
Miscellaneous chemicals.....	102,000		

Of recent years there is a marked tendency to increase American purchases of peanut oil from this source, as well as other nondutiable expressed oils, of oleaginous seeds, oleostearin, paper stock, and paints. On the other hand, the United States is purchasing much less cinchona bark, quinine salts, dutiable expressed oils, paper, wax, and miscellaneous chemicals. Several articles, such as cement, creosote oil, fish oils, paraffin, potassium sulphate, and vanilla beans, find their way to the United States occasionally, but not regularly, by the way of the Netherlands.

In the production of quinine compounds the equipment of American works is now so highly perfected that an import in quantity of such products seems more and more unnecessary. The large imports of peanut oil, other expressed oils, and oleostearin seem equally out of place in a country where the raw material is abundant and cheap. The large amount of zinc ore shipped abroad for reduction shows also a somewhat abnormal trend. The extensive purchases of calcined magnesia from the Netherlands is certainly unnecessary. The Greek magnesite employed could be brought almost as cheaply direct to American ports.

CONCLUSION.

The Dutch market for German chemical products deserves careful study. In several fields it would appear that American manufacturers might successfully attempt competition. This is more particularly the case with borax, cement, chemical foods, chrome colors, ochers, zinc white, and other pigments, Thomas meal, toilet soaps, tanning extracts, varnish, and zinc chloride.

The country offers an interesting example of what can be accomplished in building up diversified branches in this field when there is an almost complete dependence upon foreign fuel and raw material.

The evolution and present condition of the manufacture of starch, of mineral pigments, of matches, and fertilizers, as well as the industries connected with the oils and fats, are most instructive in this connection.

With the extension of American trade in the lands bordering the Pacific, the well-organized system of distributing chemical products from the Netherlands to meet the demands of Japan, China, and the Indies should be carefully kept in view. The increasing demand for chemicals in the Dutch colonies is an additional factor worthy of attention.

NORWAY.

INTRODUCTION.

Numerous factors have combined to retard the industrial progress of Norway. The climate is severe, coal is lacking, the mineral deposits are not easily accessible, the area of tillable land is very limited, and the industrial education of the people is not advanced.

Less than 3 per cent of the land is under cultivation, about 25 per cent is covered by forests, and the remainder consists essentially of moors, mountain pastures, lakes, and marshes. The conditions of life have been comparatively hard and emigration extensive. Exports to other countries have been limited chiefly to timber and the products of the extensive fisheries.

There is, however, now a marked change for the better. Norway bids fair to develop into an industrial state of considerable importance, and the chemical industries are the ones coming most prominently to the fore in the movement. The first step forward was taken in the development of the wood-pulp industry. The second, and most important for Norway's future, was the utilization of the country's magnificent water power for the establishment of electro-technical and, more especially, of electrochemical industries on a scale impossible in any other European land.

The general movement forward in the manufacturing industries of the Kingdom and more specifically in the various branches of applied chemistry may be measured by the growth during the decade 1897-1908. It should be stated, in this connection, however, that a very noticeable increase in the establishment of new factories, mills, etc., began in 1890. It reached its maximum in 1899. There was a decline in the rate until 1904, when a new period of activity set in, and has continued uninterruptedly until the present time.

During the decade ending 1908 there was in Norwegian industry an increase of 45 per cent in the number of "years of work," i. e., the total number of days of work in a year divided by 300. This increase is five times greater than the increase of population. During the same period there was an increase of 159 per cent in chemical manufacturing branches. There was an absolute increase of \$21,440,000 in the amount of wages paid to operatives, representing an advance of 82 per cent. This advance in chemical industries amounted to 333 per cent.

The average annual wage for all operatives in all industries was \$210.38 in 1897; in 1908, \$264.52, an increase of 26 per cent. In chemical industries the average annual wage advanced 67 per cent during the period. The average daily wage of adult operatives in all industries was \$0.82 in 1900 and \$0.92 in 1908.

STATISTICS OF CHEMICAL AND ALLIED INDUSTRIES.

In 1897 there was, on an average, $1\frac{1}{2}$ horsepower of motive force (equal to the work of 25 men) employed per operative in Norwegian factories. In 1908 it had increased to $2\frac{1}{2}$ horsepower. The average establishment employed 45 horsepower in 1897 and 76 in 1908.

The following table has been compiled to show the exact status of the Norwegian chemical industry in 1908, giving data on each separate branch. The classification of the Norwegian census is followed.

Industries.	Factories.	Operatives.	Average daily wage.	Horsepower.
CHEMICAL INDUSTRIES PROPER.				
Bone grinding	4	10	\$0.72	95
Calcium carbide	7	1,158	1.20	59,350
Chemicals:				
Heavy	13	429	.94	729
Minor (ink, blacking, etc.)	19	80	.61	61
Colors	8	66	.84	108
Electrochemicals	9	675	1.18	40,045
Explosives	8	133	.90	235
Fertilizers	13	132	.69	638
Glue	2	57	.76	142
Insulating material	3	11	1.36	12
Matches	5	918	.73	464
Pharmaceutical product	10	52	.60	23
Tar paper	2	8	.72	.....
Varnishes	3	12	.79	.....
Total	106	3,741	.....	101,902
CANDLES, OILS, POWER, ETC.				
Candles	2	25	.47	8
Electric power, centrals	53	459	1.10	137,167
Gas works	6	57	1.00	34
Oils and by-products	17	376	.88	896
Perfumes	1	6	.77	.....
Petroleum:				
Briquetting	1	4	.78	3
Refining	2	56	1.06	37
Soap	39	338	.72	158
Steam power houses	3	5	1.01	367
Train oil:				
Refining	36	160	.76	33
Rendering	15	87	.80	73
Above combined	9	32	.85	.....
Total	184	1,005	.....	138,777
ALLIED INDUSTRIES.				
Cement	1	160	.96	1,360
Copper smelting	4	232	1.00	1,100
Glass	9	1,143	.84	214
Iron works	4	58	.89	320
Mining of apatite, minerals, etc.	66	511	.86	65
Ore mining	111	4,877	1.13	16,016
Paper	33	3,492	.91	19,006
Tanneries	78	576	.87	860
Treatment of minerals	6	168	.73	531
Wood pulp:				
Chemical	23	4,563	1.00	27,307
Mechanical	66	3,475	.94	108,188
Total	401	19,255	.....	174,967
Grand total	691	24,601	.....	415,646

HEAVY CHEMICALS—UTILIZATION OF KELP.

In regard to most chemical products Norway is still largely dependent upon other countries. Apart from her electrochemical industries, there is a fair development of the manufacture of matches, cellulose, fertilizers, oils, candles, iodine, and oxalic acid.

The heavy chemicals are imported chiefly from Germany and Great Britain. Sulphuric acid is manufactured cheaply, as the Norwegian pyrites is of excellent quality and is shipped in large quantities to other countries. The product of the three acid works in active operation is used chiefly for the manufacture of superphosphate and is inadequate to cover the needs of domestic industry. There is an annual import, valued at \$42,000. Five small establishments furnish washing soda, in crystals, but the main supply of soda ash, caustic soda, Glauber's salt, and bleaching powder is secured from Germany and elsewhere, as the country is dependent upon imported salt.

The utilization of kelp as a source of iodine and potash salts continues to be a prominent industry on the shores of Norway. As in the case of Scotland, Normandy, and Japan, conditions seem to enable this time-honored branch still to maintain the competition with Chile iodine. In view of the exhaustion, within a measurable time, of the Chile nitrate deposits, it is well that the kelp industry is kept alive, and that studies are made to perfect its processes. There are nine establishments along the Norwegian coast occupied with this branch. Besides supplying the home demand, they exported in 1910 iodine to the value of \$53,000 and 2,318 metric tons of kelp ash, valued at \$64,000 (metric ton=2,204.6 pounds). The current price of the latter is \$27.34 per metric ton. Less is done in Norway than in Scotland to extract in a commercial form potash salts from this ash, although all of the kelp works furnish potash fertilizers. There is, however, a process in use for extracting from the kelp, before incineration, a highly mucilaginous substance that is a combination of potash with an acid present in seaweed. It is used to some extent in finishing textiles and is brought into commerce under the the name of "norgine."

OXALIC ACID—COPPER PIGMENTS—MATCHES.

One large lumber firm at Frederiksstad carries on very successfully the manufacture of oxalic acid. It is made by fusing sawdust with a mixture of the caustic alkalies. Sodium oxalate is separated by crystallization from the solution of the fused product and transformed into calcium oxalate by treatment with milk of lime. The pure acid is secured from the calcium salt by the usual treatment with sulphuric acid. The export of oxalic acid, amounting to \$37,000 in 1910, goes chiefly to the United States. The firm in question manufactures also such oxalates as are demanded in commerce.

The manufacture of copper pigments for use on the hulls of both wooden and steel vessels is highly developed in Norway, as is to be expected in a country possessing so extensive a mercantile marine. Nine establishments make a specialty of this product, and there is an annual export valued at \$58,000.

The manufacture of matches has long been established in Norway. In 1910 the exports reached 5,230 metric tons, valued at \$532,000. The Norwegian factories manufacture chiefly the ordinary friction sulphur match. There is a very limited production of safety matches.

WOOD PULP AND PAPER.

The production of mechanical and chemical wood pulp has likewise assumed large dimensions in Norway, where conditions resemble so closely those existing in Sweden. The Norwegian spruce, with its low percentage of resin, seems exceptionally well adapted for the industry. Fears are often expressed in Norway, as in other lands, that the forest wealth is being sacrificed too rapidly to the growing demands of the pulp industry. In 1910 the export reached 640,000 metric tons, of which Great Britain purchased two-thirds. Closely connected with this branch is paper manufacture, the exports amounting in 1910 to 138,500 tons. Of this, 70 per cent, chiefly printing paper and packing paper, went to Great Britain, and the remainder was shipped to Hamburg.

FISH OILS—SUPERPHOSPHATE AND AMMONIUM SULPHATE.

The vast fisheries of Norway furnish a large portion of the country's contribution to international trade. Fish oils are an important item. Sixty establishments are concerned with the varied products, chiefly those derived from the seal, whale, herring, and cod. The total annual exports of fish oils range from 4,000,000 to 4,500,000 gallons. In 1910 the exports of cod-liver oil for medicinal use reached 1,453,000 gallons.

An important item in the full utilization of the products of the fisheries is the extensive manufacture of fish guano, fish-bone meal, powdered whale flesh, and powdered herring and other fish. A large number of firms are engaged in this branch. Not only are the needs of Norwegian agriculture fully met, but there is a large surplus for exportation. The value of exports in 1910 was about \$650,000.

There are three factories making superphosphate, and the import from abroad amounts to but \$59,000 per annum. Norway is one of the few countries possessing ample deposits of apatite. The annual output covers the domestic needs and there is a small export. Norwegian agriculturists, however, use large quantities of Thomas slag, and the demand is met almost entirely by foreign importation. The annual value is \$224,000.

Ammonium sulphate is supplied by four of the leading gas works in the country.

ELECTROCHEMICAL INDUSTRIES.

It is in the recent establishment of electrochemical industries upon a grand scale that Norway has disclosed her latent power as a coming factor in the field of applied chemistry. The vast, hitherto almost neglected, water power is now being harnessed, one factory after another is coming into existence, and soon the Kingdom will present a remarkable exhibit of varied chemical industries, contributing largely to the world's markets and enriching rapidly the land.

This change began in 1899, when the first calcium-carbide factory was built. The number of works has steadily increased until now there are seven in operation. In 1905 the first air-nitrate works began operation. Now a second, on a much larger scale, is about to open, and others are planned. In addition, there is a factory for cyanamide, one for sodium, one for aluminum, one for nickel, one for ferrosilicon, and one for electrosteel. There are also several smaller

experimental plants. The products of these factories exported in 1910 had the following values: Calcium carbide, \$1,627,000; calcium cyanamide, \$184,000; calcium nitrate, \$507,000; sodium nitrate, \$58,000; sodium nitrite, \$309,000; aluminum, \$437,000; sodium, \$63,000; ferrosilicon, \$192,000; total, \$3,377,000.

The exported products in the above categories were valued at \$2,717,000 in 1909. The annual increase at present in the value of electrochemical products, as far as it can be measured by export statistics, is thus \$660,000.

CALCIUM CARBIDE—CALCIUM CYANAMIDE.

The manufacture of calcium carbide was the pioneer electrical industry in Norway, and considerable English capital has been invested in this branch. A French company operates one plant at Hafslund. The Kellner Partington Paper Pulp Co. at Borregaard is a good example of foreign investment in Norway. The company utilizes 24,000 horsepower, and employs 3,000 workmen in its carbide factory, ferrosilicon works, and large pulp mill. It is the largest industrial establishment in the Kingdom. The Albion Products Co. at Notodden, and the Alby United Carbide Factories at Odda, are two other large English undertakings. At Trondhjem, the Meraker Carbide & Smelting Works have added to their extensive works plants for producing ferrochrome and ferrotitanium. The seven carbide works employ a total of 60,000 horsepower. They are all located on the coast or on navigable rivers, and manufacture almost exclusively for exportation. In 1910 they shipped 50,579 metric tons at an average price of \$32.16 per ton. The average daily yield per horsepower is roughly estimated at $2\frac{1}{3}$ kilos, or 843 kilos in the year. In German factories the yield ranges from 3 to 5 kilos, as compared with a theoretical maximum of 8 kilos. The equipment of the carbide factories in Norway is essentially the same as that of the American factories.

An English company, the Northwestern Cyanamide Co., has built large works at Odda, on the Hardanger Fjord, and established on a successful basis the manufacture from atmospheric nitrogen of calcium cyanamide, which is competing with Norwegian calcium nitrate for recognition as the most economic form in which the air can furnish nitrogenous compounds for the needs of agriculture. The firm shipped 752 metric tons in 1909 and 4,281 tons in 1910. The price is \$42.88 per metric ton. The industry is evidently on a firm footing, and finds a market for its products, as do the similar works in Germany.

AIR NITRATES—SODIUM.

At Notodden, in 1905, the first factory for manufacturing nitric acid directly from the elementary gases of the atmosphere was erected. In an enlarged form it now gives occupation to 500 workmen, and is daily demonstrating the remarkable possibilities of this new factor in chemical industry and in economic evolution. The factory furnishes all the nitrates required by Norway in agriculture and the arts, and is shipping constantly increasing quantities to foreign countries. The exports for two years were as follows: 1909—

calcium nitrate, 9,422 tons; sodium nitrite, 2,577 tons; sodium nitrate, 592 tons; 1910—calcium nitrate, 13,531 tons; sodium nitrite, 3,200 tons; sodium nitrate, 1,074 tons.

During 1911 the manufacture of ammonium nitrate for use in making explosives has been introduced upon a large scale, as it is profitable at present prices. Ammonia is imported from England, and after conversion into the nitrate is shipped back. A much larger factory is nearing completion at Saaheim and will be put in active operation before the close of 1911.

A single factory at Vadheim, on the west coast, is manufacturing sodium very successfully. The export in 1909 was 179 tons. The price is \$0.536 per kilo, or \$0.243 per pound. The process employed is that of the direct electrolysis of fused anhydrous caustic soda. Fusion vessels and cathode are of iron, and the anode is of nickel iron. The success of the operation depends largely upon the pains taken to keep the temperature of the bath within the narrow limits of 310° to 330° C. and the rapid removal from the cathode of the liberated metal. There is an increasing demand for sodium for use in making sodium cyanide, sodium amide, and especially sodium peroxide.

ALUMINUM AND FERROSILICON.

One large factory at Christianssand is devoted to the electrolytic production of aluminum. The process is practically identical with that employed in the large American works. The export of the metal was 486 metric tons in 1909 and 1,019 tons in 1910. This is equivalent to one-ninth of the annual American production. The Norwegian aluminum is sold at \$0.43 per kilo. A considerable amount is employed in equipping the air-nitrate works, as the large conduits for acid gases and the piping for nitric acid are all made of this metal.

The demand for ferrosilicon, so indispensable in the modern metallurgy of iron, is rapidly growing, as shown by the exports from both Norway and Sweden to other countries. In 1909 Norway shipped 2,645 metric tons abroad; in 1910 the export reached 5,121 tons. Much of the output is made in the electric furnaces at Borregaard.

DECREASED OUTPUT OF NICKEL—ELECTROLYTIC REFINING.

Norway possesses extensive deposits of nickel ores, much of it containing as high as 2 per cent of the metal. In former years nickel mining was of some importance, but competition with the richer ores of Canada and the United States could not be maintained, and most of the mines ceased operation. During the closing decade of the last century the annual production of nickel sank to 7 tons. Since 1900 the industry has revived, and there is an annual output now of 70 tons, nearly all of which is used in the Kingdom. In 1909 the only mine worked, that of Eije, yielded 5,770 tons of ore containing 1.1 per cent of nickel. In the smelting works 2.77 tons of matte are obtained from 100 tons of ore. This matte contains 40 per cent of nickel and 25 per cent of copper. It is refined in the new electrolytic works at Christianssand, which are equipped for an annual

production of 400 tons of the metal. The production of electrolytic nickel is a much more complicated operation than are those yielding aluminum or sodium. The copper-nickel matte is used as anode in a weak acid bath. Both metals are dissolved and pure copper is deposited on the cathode. At a certain point, when the electrolyte contains in solution a relatively large percentage of nickel, the current is interrupted. The remaining copper is first removed from the solution (by hydrogen sulphide) and then the iron is removed with the customary precipitants. From this purified and heated solution nickel is deposited electrolytically, insoluble anodes being used. The electrolytic nickel has a high degree of purity and is fairly compact. The total consumption of electricity is relatively large and the process can be employed with advantage only where the cost of the current is exceptionally low, as is the case in Norway.

ELECTRIC SMELTING.

The success that has followed the experimental trials of the Gronwall furnace for the electric smelting of iron ores, first at Domnarfvet, in central Sweden, and later on a larger scale at Trollhattan near Gothenburg [see Daily Consular and Trade Reports for May 6, July 19, and Oct. 14, 1911], has demonstrated beyond question the economic and technical advantages of this new process. The Norsk Electrometal Co. has promptly secured patent rights for Norway, and two companies are now constructing electric iron-smelting works under their licenses. The Hardanger Elektriske, of Staalwerk, is erecting two furnaces at Odda that will use 5,800 horsepower from the Tysse fall. The company controls in all 15,000 horsepower at this point. At Arendal the Arendals Fosse-Compagni is building furnaces that will utilize 6,000 horsepower, and is able to increase it to 30,000.

A somewhat different type of smelter is under construction near Notodden by the Tinfoss Jernoers Aktieselskab, which will use at first 5,000 horsepower and can increase it, if necessary, to 15,000. Unquestionably within a few months the electric manufacture of an excellent grade of iron will be established in Norway on a good working basis.

The electric-smelting industry promises much for the country. In earlier years Norway possessed a flourishing iron industry, but saw it gradually decline as the fuel became more and more expensive. The land is rich in iron deposits, most of which are too remote to permit of advantageous mining at present. The Norwegian magnetite is not rich enough to warrant its export, and it is too hard for English smelters. If exported at all it must usually be previously concentrated and briquetted, involving considerable expense. This magnetic iron ore, however, frequently contains sufficient lime to be self-fluxing. When adequate and cheap water power is near the mines, not only the magnetic ore, but the low-grade ores not worked at all now can easily be turned into first-class steel billets and offer a large margin of profit at present prices. It may be that Norway will rank eventually among the prominent iron-producing countries of Europe, as but little is known about the full extent of its mineral wealth, especially in the northern, less accessible regions.

ELECTRIC STEEL FURNACE.

Active steps are also being taken to introduce the electric steel furnace. The Hardanger company is installing one requiring 800 horsepower, and other plans are on foot. The fine grade of iron obtained from an electric smelter with the use of charcoal is almost free from manganese and silicon. If brought into a mixture heated with gas and then refined in an electric furnace, the steel produced should be of an exceptional quality.

All of these plants and projects are dependent upon the continuance of the cheap rate for water power in Norway. In Sweden the cost per annual horsepower is apt to range above 50 crowns, or \$13.40. In Norway rates vary usually between \$5.40 and \$10.70. There are some cases where the cost is even as low as \$4.

In addition to the foregoing enterprises, Norwegian capitalists are discussing the establishment of electric works for zinc smelting, for nickel smelting, and for the combined electric smelting of copper ores and the electric refining of the metal.

STATISTICS OF MINES AND METALLURGICAL PLANTS.

The following table shows the condition of the mines and metallurgical plants in 1909. Comparative figures of production for 1896 are added.

Ores.	Metric tons.		Value in 1909.	Miners and operatives in 1909.
	1896	1909		
Apatite.....	1,485	1,364	\$18,000	.....
Copper.....	36,956	42,612	450,000	2,243
Feldspar.....	15,568	36,439	127,000	.....
Gold.....	.....	.....	2,000	47
Iron.....	6,510	40,389	79,000	681
Lead and zinc.....	452	983	6,000	262
Molybdenum.....	1	30	12,000	46
Nickel.....	422	5,770	27,000	78
Pyrites:	.....	.....	.....	.....
Arsenical.....	.....	160	2,000	4
Iron and copper.....	87,867	282,806	1,638,000	1,867
Rutile.....	33	83	19,000	.....
Silver.....	400	2,729	150,000	264
METALS SMELTED.				
Cobalt compounds.....	1	.....	.....	.....
Copper.....	1,112	1,594	445,000	116
Nickel.....	7	70	29,000	57
Pig iron.....	336	.....	.....	.....
Silver.....	4.8	7.8	134,000	11

In 1910 Norway purchased iron and steel to the amount of \$4,581,000 and manufactures of iron and steel valued at \$4,832,000. Imports of other metals reached \$1,397,000, and other metal manufactures, \$6,243,000.

TRADE STATISTICS.

It will not be easy for Norway to introduce the essential features of modern chemical industry apart from the distinctively electrochemical branches. The dependence upon other countries for most

of its chemical supplies is shown by the following table of such imports for 1910. Countries of origin are indicated in the order of their importance.

[Ar., Argentina; Aus., Austria; B., Belgium; Den., Denmark; F., France; G., Germany; I., Italy; N. Netherlands; R., Russia; S., Sweden; Sp., Spain; U. S., United States; U. K., United Kingdom.]

Articles.	Value.	Countries of origin.	Articles.	Value.	Countries of origin.
FATS, OILS, TAR, GUMS.			COLORS—continued.		
Animal fats.....	\$2,393,000	S., G., N., U.	Tar pigments for ships' hulls.	\$28,000	U. N., G., N.
Camphor.....	3,000		Vitriols.....	4,000	
Oils:			White lead and zinc white.	144,000	G., N., U. K., B., U. S.
Fish.....	885,000	S. America.	Other pigments.....	1,000	
Lubricating.....	264,000		Varnishes.....	91,000	
Train.....	330,000	Spitzbergen, Faroe.	EXPLOSIVES.		
Vegetable.....	2,400,000		Dynamite, etc.....	15,000	
Volatile.....	153,000		Fireworks.....	6,000	
Other fats and oils.....	5,000	F., I., Sp.	Powder.....	4,000	
Petroleum.....	1,372,000		MINERALS, ETC.		
Resin.....	240,000		Bauxite and cryolite..	168,000	
Shellac.....	23,000		Coal.....	7,340,000	U. K.
Stearic and palmitic acids, paraffin.	115,000	K., F., Ar., U. K., N., G.	Coke.....	911,000	U. K., N., G.
Tar:			Gypsum.....	28,000	
Coal.....	10,000		Kainite.....	116,000	
Wood.....	70,000		Sal.....	595,000	I., Sp., U. K., N. Africa.
Turpentine.....	2,000		CHEMICALS.		
Wax.....	12,000		Alums.....	44,000	
MANUFACTURES OF FATS, OILS, ETC.			Aluminum.....	11,000	
Blacking.....	27,000		Ammonia and salts...	116,000	
Candles:			Ammonium carbonate.	5,000	
Stearin and tallow.	5,000	S., G., N.	Argols.....	7,000	
Wax.....	1,000		Bleaching powder...	26,000	
Cleaning powders and washes.	3,000		Borax.....	9,000	
Cosmetics.....	13,000		Boric acid.....	2,000	
Glue.....	62,000		Calcium acetate.....	28,000	
Glycerin.....	108,000		Calcium carbide.....	4,000	
Hair oil.....	1,000		Carbolic acid.....	2,000	
Perfumes.....	9,000		Carbonic acid.....	500	
Printer's ink.....	38,000		Cement.....	140,000	G., S., U. K., B.
Soap:			Creosote and oils.....	29,000	
Toilet.....	28,000	S., U. K., G., F., U. S.	Ethers:		
Other.....	51,000	U. K., S., F., G.	Sulphuric.....	600	
COLORS.			Other.....	5,000	
Aniline dyes.....	203,000	G., N., U. K., B., Switz.	Fertilizers.....	51,000	
Caramel (for liquors)..	9,000		Glauber's salt.....	67,000	
Catechu and gambier.	15,000		Hydrochloric acid....	4,000	
Chalk, barytes, china clay.	130,000		Nitric acid.....	2,000	
Chemicals used in dyeing.	38,000		Phosphorus.....	17,000	
Colors in tubes.....	12,000		Potash.....	47,000	
Divi-divi.....	21,000		Potash, caustic.....	12,000	
Dyewood extracts.....	11,000		Potassium chlorate...	50,000	
Indigo.....	14,000	G., N.	Saltpeter.....	45,000	G.
Lampblack, graphite.	10,000		Soda ash.....	222,000	G., B., U. K.
Ochers, umbers.....	32,000		Soda, caustic.....	16,000	
Pigments in oil.....	8,000		Sodium nitrate.....	12,000	
Prepared colors in packets.	11,000		Spirit, denatured....	4,000	
Red lead.....	40,000		Sulphur.....	248,000	U. K., Sp.
			Sulphuric acid.....	42,000	N., G., S., B.
			Superphosphate.....	59,000	
			Thomas slag.....	224,000	
			Water glass.....	5,000	
			Miscellaneous.....	61,000	

EXPORTATION OF CHEMICAL GOODS.

The exports of chemical supplies from Norway in 1910 are given in the following table, the countries of destination being given in the order of importance:

Articles.	Value.	Destination.	Articles.	Value.	Destination.
FATS, OILS, TARS, ETC.			ORES, ETC.—continued.		
Bone fat	\$28,000	S., U. K., F.	Feldspar	\$151,000	G., B., U. K., F., N.
Coal tar	27,000		Graphite	9,000	
Glue	32,000	U. K., S.	Iron ore	223,000	N., U. K.
Glycerin	33,000		Magnesite	18,000	
Oils:			Molybdenite	5,000	
Linseed, etc.	1,000	S., G.	Pyrites	1,880,000	U. K., G., N., B., F.
Lubricating	11,000	S., R., Iceland.	Pyrites, arsenical	2,000	
Tar	1,000		Pyrites, cinder, rich in copper	138,000	S., B., G.
Train and cod-liver ..	2,064,000	N., G., S., Aus., B., U. K.	Quartz	8,000	G., R.
Pitch	13,000	S., R., B.	Rare minerals	6,000	
Stearin, etc.	23,000	N., G., U. K.	Rutile	4,000	
			Zinc ore	20,000	
VARIOUS MANUFACTURES.			METALS.		
Explosives	4,000		Aluminum	437,000	
Matches	532,000	India, U. K., U. S., G., B., N. Africa.	Copper	358,000	U. K., G.
Soap	3,000	S., Iceland.	Ferrosilicon	192,000	
Wood pulp:			Sodium	63,000	
Chemical—			Zinc	412,000	
Dry	6,255,000	U. K., U. S., F., B., Mex., G., N., I.	MISCELLANEOUS.		
Wet	27,000	U. K., B., N., U. S.	Ammonium sulphate ..	21,000	
Mechanical—			Calcium carbide	1,627,000	
Dry	269,000	F., G., Sp., U. K., Ar., I., B., U. S.	Calcium nitrate	507,000	G., U. K., N., Den., F., B.
Wet	4,029,000	U. K., F., B., N., Den.	Cement	44,000	
FERTILIZERS.			Cyanamide	184,000	G., U. K., R.
Bone meal	36,000	S., G., U. S., N.	Iodine	53,000	G.
Fish guano	404,000	G., F., U. S., U. K.	Kelp ashes	64,000	U. K.
Fish meal, etc.	210,000		Oxalic acid	37,000	U. S., U. K., I.
ORES, ETC.			Pigments:		
Apatite	9,000	G., U. K.	Copper	58,000	U. K., Den., China, G.
Copper-nickel ores ..	47,000		In oil	3,000	
			Other	3,000	
			Soda ash	1,000	
			Sodium:		
			Nitrate of	58,000	
			Nitrite of	309,000	
			Zinc white	600	

TRADE WITH THE UNITED STATES.

The exports to the United States are comparatively limited, the figures for 1909 being as follows:

Articles.	Value.	Articles.	Value.
Aluminum	\$30,000	Matches	\$58,000
Calcium carbide	8,000	Oxalic acid	43,000
Cement	1,500	Wood pulp:	
Cod-liver and other fish oils ..	97,000	Chemical—	
Ferrosilicon	18,000	Dry	1,192,000
Fertilizers:		Wet	5,000
Bone meal	3,000	Mechanical—	
Fish guano	12,000	Dry	7,000
Powdered herring ..	8,000	Wet	200
Other	6,000	Other chemical products ..	13,000

Norway's imports from the United States for 1909 were valued at \$5,799,000. They included: Blacking, \$700; coal, \$26,000; chemicals, drugs, dyes, and medicines, \$7,500; soap stock, \$8,000; mineral oils, \$899,000; cottonseed oil, \$242,000; and paraffin, \$500.

STRIKING FEATURES OF NORWAY'S CHEMICAL INDUSTRIES.

In surveying the chemical industries of Norway there are several features worthy of careful study by the American economist. First and foremost is the systematic and exhaustive manner in which the abundant water power of the country is now being regulated, stored up, and pressed into the service of the steadily increasing group of electrochemical industries. The best talent in the nation is enlisted in this cause, and the way is rapidly being opened for Norway to assume an industrial position commensurate with its geographical size and admirable facilities for maritime transportation.

In another field Norway has shown her ability to develop an industry, fitting in well with her enormous lumber interests, and that is in the manufacture of oxalic acid. It is a source of wonder that no attempt has yet been made to organize this branch of manufacture in the vicinity of some of the great American lumber centers, where sawdust, the primary raw material, is without value except as fuel. The United States buys annually oxalic acid from Norway to the value of \$43,000, and from Germany to the value of \$65,000. The American market should not be dependent upon European manufacturers for a chemical the preparation of which is so comparatively simple.

As a market for American chemicals, Norway offers less of a field than the neighboring Scandinavian States, on account of the limited extent to which many industries consuming such products are developed at present. The character of the demand is much the same as in Denmark and Sweden. The quantity is relatively less.

SWEDEN.

INTRODUCTION.

Sweden is a land in which chemistry has played an important rôle from a comparatively early date. Scheele and Berzelius were among the most noted pioneers in the formative period of the science, and no less than 20 of the known chemical elements have been discovered by Swedes. The Kingdom owes to three factors its past and present position in technical chemistry. The first is a fairly abundant and diversified mineral wealth. Swedish iron and copper once dominated the world's markets. While no longer leading in quantity, Sweden still occupies a foremost position with regard to the quality of its metal products and the high technical standard of its mining and metallurgical equipment.

A second feature is the enormous extent of the country's forests. Once contributing the necessary charcoal for its choice product of iron, they now furnish the raw material for an enormous industry—the manufacture of cellulose in its varied forms.

The third factor is Sweden's abundant water power. The coal deposits of the land are unfortunately limited and of inferior quality. The annual output is 305,000 long tons. In earlier days the forests supplied fuel. Now that timber possesses a greater value and the supply is more limited it has been necessary to import coal from abroad to the extent of 3,000,000 tons annually.

With the advent of electric power and its economical transmission it has been possible to utilize the waterfalls on a most extensive scale. Electrotechnical industries have promptly availed themselves of this opportunity. The total available water power of the Kingdom is estimated at over 4,000,000 horsepower. About one-ninth has thus far been harnessed for industrial purposes. Each year at present there is an additional increase of over 100,000 horsepower. In 1911 it is estimated that this increase will be about 115,000 horsepower. Owing largely to this rapid exploitation of her vast water power, Sweden is changing from a producer of raw materials to a predominantly manufacturing land. Modern industrialism is rapidly invading every field of national activity.

EXPANSION OF THE CHEMICAL INDUSTRY.

The chemical industry of the country is confined chiefly to inorganic branches. Apart from the wood pulp and the products of the electrochemical branches, it is in most cases inadequate to meet the demands of the home market of a population of 5,500,000. It is, however, expanding steadily, more rapidly than the growth of population.

According to the census of 1900 there were 256 chemical factories, employing 2,644 workmen, with annual products valued at \$4,095,000. To these should be added 187 factories producing oils, tar, etc., with 2,434 workmen and an output of \$5,650,000, and the match industry, with 20 factories, 6,102 workmen, and products valued at \$2,665,000. Paper and allied branches were credited with 159 factories, 18,490 workmen, and an output of \$8,130,000. The metallurgical industries give employment to 16,876 workmen, and the products are valued at \$49,050,000. For purposes of comparison the statistics of other leading industries are here given: Mining, 13,861 workmen, output \$5,430,000; metals and machines, 56,222 workmen, output \$44,840,000; textiles, 37,187 workmen, output \$36,100,000.

The 256 establishments classified by the census as chemical works are subdivided as follows:

Character of products.	Factories.	Workmen.	Value of products.
Inorganic acids, bases, and salts.....	32	291	\$683,000
Fertilizers.....	72	921	1,402,000
Explosives.....	19	664	897,000
Colors and miscellaneous.....	133	763	1,113,000

For its supplies of most heavy chemicals Sweden is still to a great degree dependent upon other European countries.

INORGANIC ACIDS, BASES, AND SALTS.

Sulphuric acid is made largely in connection with the manufacture of superphosphate. In seven factories, with 39 workmen, there was an annual output of 35,108 metric tons (metric ton=2,204.6 pounds). Twenty years before the output was but 4,000 tons. The output nearly covers the domestic demand. Pyrites is used chiefly in the works, and is imported from Norway and Spain. There is also a considerable consumption of Sicilian sulphur.

There is but one factory for caustic soda and bleaching powder. Both articles are imported chiefly, as is also the case with soda and its various by-products and derivatives. In the list of salts, however, there is one notable exception in the case of potassium chlorate. This compound, so important in the domestic match industry and in the manufacture of explosives, is now one of the leading staple products of Sweden and is extensively exported. The electrolytic process by which it is produced was devised in 1893 by Director O. Carlson, who started the first electrochemical establishment in Sweden. In 1900 the two factories employed 215 workmen, and the chlorate produced was valued at \$214,000. In 1909 imports of chlorate had sunk to 207 tons, and the Swedish factories were not only meeting the home demand but exporting annually 1,400 tons to other countries. The industry uses potassium chloride from Stassfurt as its raw material.

Carlson's method is an advance upon preceding processes for the electrolysis of alkaline chlorides, as he does not use diaphragms in the electrolytic bath and maintains a continuous operation. Cathodes of iron are employed, but the anodes, which were originally of carbon, are now of platinum-iridium gauze. Formerly the baths

were kept slightly alkaline by additions of caustic potash or lime. Now they are kept slightly acid, as free hypochlorous acid favors the formation of chlorate. Small amounts of potassium bichromate are also added to prevent the reduction on the cathode of the potassium hypochlorite primarily formed. The process is noteworthy as the sole important instance where an electrolytic method has proved to be economically superior to an old-established process of chemical manufacture and has effectually displaced it. In Germany only one factory has tried to maintain its manufacture of potassium chlorate by the old process, using Deacon chlorine. In England the old process is likewise being gradually abandoned.

FERTILIZERS.

Agriculture is highly developed in Sweden, one-half of the population being engaged in tilling the soil, and the demand for artificial fertilizers is extensive. Although there are large amounts of apatite in the country, it is impossible to compete with the raw phosphate brought from Florida, Algiers, and the Pacific. About 29,000 tons of Chile saltpeter are imported annually. Thomas slag is worked up very advantageously, as some of the Swedish iron ores are very rich in apatite and yield with the basic Bessemer process a very rich slag. Three factories grind this slag, producing 10,000 tons annually. As the demand for Thomas iron is limited, the production will not increase materially.

A few years ago Prof. Wiborgh devised a method for utilizing the phosphoric acid in the Swedish iron ores, which carry especially large amounts of apatite. These ores are finely ground and the resultant powder submitted to the action of powerful magnets. By this means the apatite is largely freed from the iron oxide. It is then fused with soda and the phosphoric acid is brought into the citrate-soluble form of tetracalcium phosphate. The product compares favorably with Thomas slag and even superphosphate in fertilizing efficiency. A factory was started at Svarton to manufacture the so-called Wiborgh phosphate, but after a short period the works were closed.

There are numerous factories for producing bone meal, as well as bone fat and glue and animal charcoal, and a few establishments for making poudrette. Herring guano is a staple article. At Gothenburg and its vicinity there are 17 factories engaged in extracting herring oil and preparing the residual press cakes for fertilizer. The annual product is valued at \$285,000, of which \$208,000 is represented by the guano. This industry depends on the success of the annual herring catch.

In 1900 Sweden consumed 253,132 metric tons of artificial fertilizers, of which one-half were produced at home. In the course of a decade the industry has developed so rapidly that there is now a surplus of superphosphate available for export, amounting to 17,000 tons in 1909.

EXPLOSIVES.

The manufacture of explosives constitutes one of the leading industries of Sweden, largely owing to the genius and inventive ability of Nobel. In addition to dynamite his other leading invention, bal-

listite, a smokeless gunpowder consisting of a gelatinized mixture of nitroglycerin and guncotton, is manufactured. Originally the Nobel Co. prepared this powder from equal parts of the two constituents. It is now made from one part nitroglycerin and three parts guncotton. A small amount of diphenylamine is often added. Gelatinization is effected by means of a mixture of alcohol and ether (2 to 1).

Another distinctively Swedish explosive, Lamm's bellite, is manufactured to a limited extent. Its base is dinitrobenzene, and it belongs to the class of picrate powders. The growth of this branch of manufacture in Sweden has been remarkable. In 1870 there was one factory, employing 40 workmen, with an annual output of \$34,000. In 1900 there were 11 factories, with 394 workmen, and an output of \$724,000.

COLORS—CALCIUM CARBIDE AND VANADIUM SALTS.

Small establishments manufacturing coloring matters produce pigments of domestic materials, lampblack, ochers, zinc white, white lead, and cobalt blue, and prepare also, for use in solution or composition, the different organic dyestuffs, imported chiefly from Germany. There are 46 factories, employing 130 workmen, producing wares of an annual value of \$234,000.

Acetylene is widely used in Sweden, and the carbide industry was founded almost as early as in the United States. Two factories, one at Alby and the other at Trollhattan, with a total of 5,000 horsepower, produce not only enough for the needs of the domestic market, but also export annually about 1,600 tons. The actual cost of production is given as 3 cents per pound.

Sweden has in the past supplied the world's demand for vanadium compounds, vanadium chloride for the aniline-black dyeing, and ammonium vanadate for use in steel making. The exportation is now much less than formerly, for aniline black and copper sulphate and sulphide are more in use now as catalytic agents.

MATCHES.

The match industry is one of the most important in the Kingdom and has grown rapidly. Twenty factories produced matches valued at \$3,422,000 in 1909. Nine-tenths of the total product is exported. These Swedish matches are encountered all over the world, despite a very keen competition. The export interests complain of the high protective duties in most countries. In France, Spain, and Greece matches are a Government monopoly.

The Swedish factory equipment contains many devices for replacing manual labor. Lagerman's "complete machine," introduced in 1892 at the Jonkoping works, is one of the most ingenious labor-saving devices known. The match splints, already cut into the proper form by other appliances, are fed regularly into one end of this machine and emerge at the other end a finished product, packed in boxes, ready for shipment. One such machine produces hourly 3,600 boxes of matches.

Aspen wood is used almost exclusively in the match industry. It is easy to cut and porous enough to admit easily of impregnation with sulphur or paraffin. The domestic supply of aspen of good quality is now seriously reduced, and much is imported from Finland and Russia. Most of the chemicals used—phosphorus, antimony, sul-

phur, and paraffin—are imported. This was also formerly the case with potassium chlorate until the recent establishment of the Swedish electrolytic manufacture. In 1901 the Swedish Government forbade the sale in the Kingdom of matches made with yellow phosphorus. At present the manufacture of the old-fashioned matches is much less than formerly, although the Jonkoping works produce a considerable quantity in which yellow phosphorus is replaced by innocuous phosphorus sesquisulphide. In manufacturing the standard safety matches of Sweden now the splints are first soaked in paraffin, or in a concentrated solution of ammonium phosphate. The ignition mass for the heads consists of potassium chlorate, mixed with sulphur or antimony sulphide, gum, or dextrin in solution, and small amounts of powdered glass and ferric oxide. Potassium dichromate and manganese dioxide are occasionally added as oxidizers. The friction surface on the boxes is coated with a mixture of red phosphorus, antimony sulphide, and dextrin solution.

The largest factories in the Kingdom are the two at Jonkoping and the "Vulcan" at Tidholm. Under their lead nearly all the other manufacturers have combined to prevent undue competition and facilitate the export trade. This latter is carried on largely through Hamburg and London, which serve as distributing points for much of the world's trade in matches. There has been a rapid shrinkage of the export of Swedish matches to Germany, partly as a result of recent legislation. In 1909 the export was 1,655 tons, and in 1910 but 44 tons.

WOOD PULP.

The manufacture of cellulose, or wood pulp, is another highly developed Swedish industry, based also primarily upon its forest wealth. The factory for grinding wood, established at Trollhattan in 1857, was the pioneer of the pulp industry. The preparation of chemical wood pulp was introduced in 1871, the soda process being used. In 1874 came the sulphite process, Francke using calcium bisulphite, and Ekman the magnesium compound. Both of these methods are now utilized, but that of Ekman is used to a less extent on account of its greater cost; the product is, however, of a remarkable purity and gloss, and it is preferred as raw material for the finer qualities of paper. Swedish wood pulp ranks high, as the wood employed—aspens and spruce—is freer from resin than that available in most countries. The pulp factories of Sweden number 122, and in 1900 employed 6,910 operatives and produced 417,000 metric tons of pulp.

The exports of pulp reached 564,000 tons in 1909, as against 229,000 tons in 1900, and consisted of 372,000 tons of dry chemical pulp, 31,000 tons of wet chemical pulp, 46,000 tons of dry mechanical pulp, and 115,000 tons of wet mechanical pulp. The total value of the exports was \$15,372,000. Great Britain takes about 60 per cent of the export, other heavy purchasers being France, Norway, Germany, Belgium, Denmark, and, recently, the United States.

There has been a serious overproduction of wood pulp during the past three years and prices have been much disorganized. Recently the wood-pulp associations of Sweden and Norway have agreed upon a systematic limitation of the production of mechanical pulp for 1911

and 1912. The prospective reduction during the period ending January 1, 1913, is fixed at 150,000 tons. No restriction is placed on the output of chemical pulp. As a result of this agreement prices of mechanical pulp have already been materially advanced.

PAPER.

The manufacture of paper is naturally closely allied with that of cellulose. In 1909 Sweden had 66 paper mills, employing 7,725 operatives, the production amounting to 250,000 tons, of which 137,510 tons, valued at \$7,346,000, were exported. The ratio of increase is about the same as that of cellulose. Of the paper exported, 80 per cent goes to Great Britain and is used chiefly for newspapers.

Swedish filter paper for chemical purposes has maintained a world-wide reputation for a century. For a long period it was regarded as indispensable for the needs of the analyst, and the manufacturers enjoyed a practical monopoly. Rivals in other countries, especially in Germany, now compete in furnishing a filter paper carefully freed by treatment with hydrochloric and hydrofluoric acids from mineral matter. The remarkable success attained in earlier years by the largest Swedish firm was due to the use of the purest water available for manufacturing purposes and the choice of exceptionally pure raw material. The peculiar properties of the paper were largely secured by freezing it while in a moist condition. The formation of ice crystals rendered the feltlike mass sufficiently porous for the purposes of rapid filtration. This Swedish firm manufactures now a very choice grade of writing paper, made by simply dipping its filter paper into sizing.

ALCOHOL.

Another industry, that of the manufacture of alcohol, is now linked with the great cellulose interests. The customary methods of distillation are well developed in the country. There were in 1900 131 distilleries, producing annually 450,000 hectoliters (11,887,650 gallons) of spirits containing on an average 50 per cent of alcohol. Much of this is for use as a beverage. Of the total amount, 62 per cent is manufactured from potatoes, 35 per cent from maize and grain, and 3 per cent from beets and molasses. There were 429 distilleries in 1875, and only 131 at the close of the century.

The chemists of Sweden have experimented in a variety of ways to solve the problem of manufacturing alcohol from wood and thus find an additional source of revenue from the country's forest wealth. In the production of wood pulp by the sulphite method there is a waste product that the chemists have finally been able to utilize with profit in the production of alcohol. The profitable utilization of the exhaust lyes drawn off from sulphite boilers has always been a problem. For every ton of cellulose made by this process there are 10 tons of these lyes. They contain one-half of the weight of the wood originally introduced into the boilers. Among the matters present are dextrose and various other sugars, xylose, acetic acid, tannic acid, nitrogen compounds, resins, etc., as well as the calcium lignin-sulphonate, the chief product of the reaction. Of the sugars present most are susceptible of fermentation. They constitute about

1 per cent of the lyes. The treatment of the liquid is comparatively simple. It is first neutralized with calcium carbonate, after which yeast is introduced. When the fermentation is complete the alcohol produced is secured in the ordinary manner. The process yields 6 gallons of alcohol (100 per cent) for 1,000 gallons of lye. About 14 gallons are secured for every short ton of cellulose.

ALCOHOL FROM WOOD-PULP WASTE.

As may be imagined, methyl alcohol and other volatile compounds are contained in this crude alcohol. It is sold and used as denatured alcohol for heating and technical purposes. The excise rates in Sweden have been adjusted so as to aid this new industry. If the process were extended to all Swedish sulphite works, the annual output would be about 3,500,000 gallons. It is doubtful whether a sufficient demand exists for this grade of alcohol to furnish a home market for such an amount. German chemists are skeptical as to the possibility of producing the alcohol economically under existing conditions in the Empire, where, on the basis of the Swedish results, over 8,000,000 gallons could be produced annually.

In the attempts to manufacture alcohol directly from wood, investigation so far has been directed to the simple reaction involved in combining one molecule of water with one molecule of cellulose, and thereby producing dextrose, from which alcohol is obtained by fermentation. Chemically, by treatment with sulphuric acid under pressure, this change can be readily effected. From ordinary wood, alcohol amounting to 5 or 6 per cent of the original weight can be thus secured. Pure cellulose yields 15 per cent. The problem is essentially of an economic nature. It is claimed in Sweden that it has been solved, and that a method has been elaborated for utilizing the waste of the sawmills. Details are not yet given.

DISTILLATION OF WOOD.

The distillation of wood developed at an early day in Sweden, as was to be expected in a land so rich in forests. Swedish tar was exported to every land and given the preference for coating vessels and their rigging, walls, roofs, and roofing paper. It continues to enjoy its good repute, but exports are less in quantity than was the case half a century ago. There has been renewed activity during the past decade. The foreign trade in this article shows the fluctuations: 1875, imports 1,700 and exports 8,300 metric tons; 1900, imports 1,700 and exports 3,600 metric tons; 1909, imports 200 and exports 7,614 metric tons.

The industry is now centered in the northern section of the Kingdom and shipments take place chiefly from the port of Umea. Much of the tar is produced in a small way in old-fashioned tar hollows by individuals or families. There are some more modern establishments, where iron retorts are installed. The census of 1900 reported products from such works valued at \$58,000. As the exports alone of wood tar had a value of \$135,000, it is evident that the bulk of the output comes from small producers. There are now about 25 firms engaged in the business, most of them carrying it on in connection with extensive lumbering and wood-pulp interests.

LARGE COMPANY AT KILAFORS.

The Skogens Kolaktiebolag, at Kilafors, is the leading company devoted exclusively to wood distillation. It uses annually for this purpose over 100,000 cubic meters of pine wood (cubic meter = 35.314 cubic feet). A good example of the diversity of interests carried on by a Swedish company is seen in the case of the Stora Kopparbergs Bergslags Aktiebolag, of Falun. This company is said to be the oldest industrial corporation in the world, having received a royal charter in 1347 after a previous existence of over a century. For two centuries, prior to 1750, it was the chief producer of copper in the entire world. Since then, as the copper supply diminished, it has devoted itself to iron, and is to-day the leading producer of iron and steel in Sweden, owning the largest iron works in northern Europe. During the past century it gradually increased its land-holdings until it now owns 750,000 acres of forest and has become the largest exporter of forest products in the Kingdom. At Skutskar it operates what is thought to be the largest sawmill in the world, and at Kvarnsveden it lately built a combined pulp factory and paper mill at a cost of \$760,000. Its annual dividends are 14 per cent.

VARIETY OF PRODUCTS.

The Kilafors Co. and a few others, notably the Skånska At-tikfabriken, of Perstorp, furnish a wide variety of products obtained from the destructive distillation of wood. Their lists contain the various charcoals, wood naphtha of 64°, methyl alcohol free from acetone, pyroligneous acid, technical and crystallized acetic acid, formaldehyde, creosote, carbonates of creosote and guaiacol, turpentine, lampblack, tar oil, carbolineum (for the impregnation of wood), pitch, etc. Little effort is made to go further in the isolation of the numerous other constituents of wood tar, or to use those separated for the manufacture of higher derivatives.

Forty years ago factories were started in Sweden for the purpose of utilizing the stumps of spruce and other conifers, by subjecting them to destructive distillation. Apart from tar, etc., it was sought to secure more particularly the crude wood oil, used in place of turpentine. This branch of manufacture has not been very successful, as it has not been possible to free the product from a pronounced burnt odor. At present six small factories carry on this distillation. The production of resin and turpentine is strangely limited for a country so rich in conifers as Sweden. There is an annual import of 400 tons of turpentine.

LIMITED PRODUCTION OF COAL TAR.

There are 27 gas works in Sweden, but with the abundant water power and cheap electricity the industry does not expand rapidly. At Gothenburg the annual per capita consumption is 1,236 cubic feet. At Stockholm it is 3,088 cubic feet. Ammonia is collected in a few works in the form of the sulphate. The tar from the larger works is used for producing asphalt, carbolic acid, and creosote oils, chiefly for impregnating wood. The domestic supply of tar is insufficient, and there is an annual import of about 2,800 metric tons. One

reason for the limited production of coal tar is the fact that Sweden possesses no coking coals and is forced to import coke from abroad. But little is done to carry on any systematic separation of the constituents of coal tar, apart from the carbolic acid.

NOVEL METHOD OF PURIFYING COAL TAR.

A Swedish firm has introduced a novel and valuable feature into the treatment of coal tar. The Aktiebolaget Joh. Ohlssons Teckniska Fabrik, of Stockholm, has solved the problem of removing the carbon from coal tar. The black color of tar is due to the presence of a large amount of carbon in an extremely finely divided state. It constitutes about one-quarter of the weight of the crude material. As the liquid tar has about the same specific gravity as the solid carbon, the latter remains suspended. The firm in question has succeeded in completely isolating the carbon from the liquid constituents of tar, leaving the latter in the form of a clear, transparent, gold-brown liquid. Such a purified tar is evidently much better adapted for fractional distillation than the crude material, and should facilitate the separation of the hydrocarbons and other compounds with a high boiling point, an operation rendered difficult in the process of ordinary tar distillation owing to the foaming caused by the fine carbon toward the end of the operation.

The carbon separated by the Ohlsson process is totally different from lampblack in its physical properties and is distinctly of a graphitic nature. When pressed into a compact form it furnishes admirable electrodes for arc lighting and also for electrochemical work. It could probably be used with equal advantage in making crucibles, as it possesses marked superiority over retort graphite.

Details are withheld with regard to the method used for effecting the separation. In all probability light hydrocarbons are added to the tar to lower its specific gravity, and the actual separation is brought about by the use of centrifugals. The added hydrocarbons can be removed by distillation from the residual liquid tar. This process is worthy of careful study owing to its possible bearing upon the isolation of the more complicated higher boiling constituents of coal tar.

SUGAR.

Despite the northerly climate and various other unfavorable conditions, the production of beet sugar in Sweden has increased, until sugar importation has practically ceased. Beginning with 1 factory in 1876, there are now 20 in active operation, the largest producing 120 tons daily. The total annual production is about 130,000 tons. There are 9 sugar refineries employing 2,402 operatives. All factories employ the diffusion process. The industry is located entirely in the lower end of the peninsula. Seed is brought from other more-favored lands. The average yield of sugar is very high, taking all factories into consideration, being 3.5 metric tons per hectare (2.47 acres). The average yield in France and Belgium is 3.2 tons and in Germany 4 tons. The industry has been fostered by a protective tariff, amounting at present to 1.82 cents per pound. The rate of duty has varied at different times, but has never been less than 1.6 cents. A helpful factor in establishing new factories has been the

remission for five years of all taxes on such works when built at least 19 miles from any existing factory.

STARCH—GLUE—GELATIN—YEAST.

Starch is manufactured on a somewhat extensive scale, chiefly from potatoes. There are 95 factories, producing a total of 7,580 tons annually. This meets the entire domestic demand. A large share of the product is changed into glucose and used for conserves. Glue and gelatin are likewise produced in nearly sufficient quantity to meet domestic needs. There are 13 factories, employing 223 workmen, and producing wares valued annually at \$300,000. Yeast is made in several factories, the annual output being 2,785 tons.

MISCELLANEOUS CHEMICAL PRODUCTS.

In 1900 there were 14 oil factories, employing 159 operatives. The annual product was 11,736 tons of oil cake and 4,418 tons of linseed and rape oil, as well as small quantities of fish oil and train oil. In 1909 Sweden imported 16,904 tons of animal and vegetable oils, 872 tons of train oil, 684 tons of olein, and 8,017 tons of fats.

One Swedish specialty in this branch deserves note. The "Col-lanoljefabriken" has produced for a number of years an oil very highly valued for treating leather and rendering it waterproof. The composition and manufacture are kept secret, but it is supposed to be extracted from certain tropical plants. The oil is extremely viscous, can be drawn out in long strings, and repels water to a most pronounced degree. As a leather preservative it seems to render exceptional service.

The soap industry is highly developed. There are 42 factories producing annually 13,000 tons of soft soap and 3,700 tons of hard soap. Excellent toilet soap is manufactured in a few establishments. Imports of soap are relatively small. In some factories the production of scents is also extensive, the annual output being valued at \$200,000. This is about six times the value of the imports of scents.

The candle industry is so developed that it practically supplies the domestic demand. There are 3 factories, employing 312 workmen. The annual product, which includes also stearin, is valued at \$6,188,000. The imports are insignificant.

The domestic demand for varnish is very nearly covered by Swedish works. They number 15 and employ 91 workmen.

The manufacture of cement has grown rapidly of late years and is now an exporting industry. In 6 works 1,336 operatives are employed. The annual output of 126,000 tons has a value of \$1,130,000. About one-third of this is exported, chiefly to the adjacent countries.

There are Swedish concerns engaged in the manufacture of lactic acid, lanolin, fruit essences, cosmetics, and pharmaceutical preparations, and some of the last named are of international repute. Liquid carbonic acid is made in three factories, the total annual output being 415 tons.

MINING AND METALLURGY.

The mining and metallurgical interests are so closely connected with chemical industries that a few data are appended. In 1902 30,700 workmen were employed, of which 14,600 were employed in mining proper, including 10,500 in the iron mines.

The quantities of ores and minerals produced in 1902 were as follows, in metric tons: Iron ores, 2,897,000; lead and silver ores, 9,400; copper ores, 30,000; zinc ores, 49,000; manganese, 2,800; clays, 216,000; feldspar, 18,000; coal, 305,000. In 1908 the production of iron ore had increased to 4,713,000 metric tons, of which 3,444,000 were exported.

Metals were produced in 1908 as follows, in metric tons: Pig iron, 556,000; iron and steel bars, ingots, blooms, etc., 772,000; zinc, 274; lead, 277; copper, 2,807. Silver to the extent of 1,389 pounds and gold to the extent of 44 pounds were also produced.

Iron constitutes 95 per cent of the value of the metallic output. Most of the companies engaged in the production of iron and steel are partners in the Järnkontoret, an association that represents a peculiarly valuable method of organization for mutual aid and protection. [A report covering the workings of the Järnkontoret, or Iron Institute, and the progress it has made in the reduction of iron ore in electric blast furnaces was published in Daily Consular and Trade Reports for July 19, 1911.]

TRADE STATISTICS.

In the following table a detailed statement is given of the imports of chemicals, drugs, dyes, and raw material used in their manufacture, as furnished by the annual report of the Swedish customs administration for 1909. In some cases the countries of origin are added in the order of importance. In many cases the countries indicated are simply points of distribution and not of origin.

[Ar., Argentina; Austr., Australia; B., Belgium; F., France; G., Germany; N., Netherlands; Nor., Norway; R., Russia; U. S., United States; U. K., United Kingdom.]

Articles.	Metric tons.	Country of origin.	Articles.	Metric tons.	Country of origin.
Fats.....	8,017		COLORS, ETC.—contd.		
Oils, nonvolatile.....	16,904		Bronze powder.....	8	
Petroleum.....	111,485		Bronze and chromium colors.....	110	G., N.
Train oil.....	872		Catechu.....	207	G., U. K.
Camphor.....	14	G., F., U. S.	Cinnabar.....	15	G.
Gums and resins.....	4,302	F., G., B., N.	Coal-tar colors.....	687	G., Switz.
Turpentine.....	412		Colors in tubes and glass.....	13	G.
Coal tar.....	2,782	Finland, G.	Dyewoods.....	503	G.
Wood tar.....	200		Gall apples.....	16	
Barytes.....	529		Indigo:		
Cryolite.....	57		Extract.....	37	G.
Fluorspar.....	672	U. K., G.	Synthetic.....	46	G.
Magnesite.....	728	G., N., Greece.	Lampblack.....	66	G., N., U. S.
Pyrites.....	78,049	Nor., Spain.	Lithopone.....	960	
Candies.....	46	N.	Paints.....	149	U. K., G., U. S.
Cosmetics.....	11		Printer's ink:		
Perfumes.....	8		Black.....	94	G.
Soap:			Colored.....	22	G.
Toilet.....	46	G., U. K., F.	Quebracho wood.....	5,245	U. K., G., Ar.
Ordinary.....	260	U. K., G.	Red lead.....	1,003	U. K., G., N.
Albumen.....	3	G., U. K.	Red ocher.....	542	G., U. K., N.
Animal charcoal.....	186		Sumach and extract.....	56	G., Italy.
Celluloid.....	22		Tanning materials.....	6,286	G., U. K., F., R., Italy.
Collodion.....	2	G.			
Enamel material.....	102		White lead.....	510	G., U. K.
Rennet extract.....	91	D.	Zinc, white.....	2,692	G., N., B.
Rubber, artificial.....	24	F., G.	Other colors.....	2,563	G., F., N., U. K., B., Spain, U. S.
Varnishes.....	340	N., G., U. K., U. S.			
Medicines.....	137	G.			
COLORS, ETC.			CHEMICALS.		
Alizarin.....	64	G.	Alum:		
Anatto.....	11	D.	Chrome.....	65	G., B.
Blackening.....	123	G., U. K.	Potassium.....	29	G.

Articles.	Metric tons.	Country of origin.	Articles.	Metric tons.	Country of origin.
CHEMICALS—continued.			CHEMICALS—continued.		
Alum cake.....	349		Potassium:		
Alumina.....	4		Carbonate of.....	1,312	G., Austr.
Aluminium sulphate.....	1,024		Chlorate of.....	207	F., U. K.
Ammonia.....	13		Chloride of.....	1,805	G.
Ammonium:			Chromate of.....	87	U. K., G.
Carbonate of.....	137	U. K., G.	Cyanide of.....	4	G.
Chloride of.....	226	U. K., G.	Nitrate of.....	267	G.
Nitrate of.....	11	G., N.	Sulphate of.....	26	G.
Sulphate of.....	76	D.	Sulphide of (includ-	451	G., U. K.
Antimony.....	118	G.	ing Na ₂ S).		
Argols.....	19	F.	Quinine preparations...	1.3	G.
Arsenic, white.....	13	G., B.	Saccharin.....	4	G.
Borax.....	365	U. K., G.	Salicylic acid.....	4	G.
Bleaching powder.....	3,018	U. K.	Salt:		
Boric acid.....	76		Crude.....	12,174	G.
Bromine and bromides..	10	G.	Refined.....	24,143	G., U. K., N.
Carborundum.....	3	D.	Soda, caustic:		
Cement.....	12,776	G., B., U. K.	Solid.....	1,111	U. K., G., B., N.
Chloroform.....	6	G., U. K.	Liquid.....	8	
Citric acid.....	14	G.	Soda ash.....	13,490	S., U. K., B., N., Fr.
Cobalt oxide.....	3		Sodium:		
Copper sulphate (blue vitriol).	104	U. K.	Acetate of.....	36	G., B., N.
Ferrocyanides.....	11	G.	Chlorate of.....	3	F.
Ferrous sulphate (green vitriol).	945	U. K., G.	Chromate of.....	8	U. K., G.
Formalin.....	5	G., F., N.	Nitrate of.....	28,894	G.
Glycerin.....	214		Sulphite and hypo-	265	G., B.
Graphite.....	442		sulphite of.....		
Hydrochloric acid.....	2,134	G.	Sulphate of.....	20,226	U. K., G., B., N., U. S.
Iodine and iodides.....	4	G.	Sulphur:		
Lanolin.....	6	G.	Crude.....	23,255	Italy, U. K.
Lead acetate.....	61	G., N.	Flowers.....	59	Italy, G., R.
Lime.....	1,146	Nor., D.	Refined.....	3,521	U. K., Italy, G.
Lysol.....	1	G.	Sulphuric acid:		
Magnesium:			Fuming.....	509	G., N.
Chloride of.....	425	G.	Ordinary.....	1,446	G., N.
Sulphate of.....	140	G.	Superphosphate.....	2,845	B., U. K.
Naphthalene.....	74	G.	Tartaric acid.....	36	G., F.
Nitric acid.....	89	G.	Thorium nitrate.....	1.7	G.
Nitric ether.....	5	G., N.	Tin and lead oxides...	58	
Nitrobenzene (mirban oil).	46	G., N.	Tin salts.....	1	G.
Opium.....	1	G.	Water glass.....	405	G., U. K., Nor. N.
Oxalic acid.....	38	G.	Zinc.....	8	G.
Phosphorus.....	88	U. K.	Zinc chloride.....	50	U. K., G.
Phosphoric acid.....	25	G.	Other chemical prepa-	1,444	G., U. K., Nor. U. S., N.
Potash, caustic:			rations.		
Liquid.....	21	G., B.			
Solid.....	4	G.			

¹ Bushels.

It will be seen from the table that Sweden offers a fairly good market for a great variety of chemical products. Germany is the chief source of supply. The United States furnishes 78,143 tons of petroleum, 4,314 tons of lubricating oils, 3,913 tons of molasses, 812 tons of fats, 1,157 tons of cottonseed oil, 1,543 tons of corn oil, and 284 tons of other oils.

EXPORTATION OF CHEMICAL GOODS.

In the following table are shown the Swedish exports in 1909 of chemicals and goods in the manufacture of which chemicals are used:

Articles.	Metric tons.	Destination.	Articles.	Metric tons.	Destination.
Fats.....	735	F., G., N., B., U. K., Nor. U. K., G.	Wood pulp.....	564,000	Brazil, D., Austr., U. K., Ar., F, South Africa.
Oils and olein.....	1,299		Ammonium sulphate..	331	
Coal tar.....	4,461		Calcium carbide.....	1,556	
Wood tar.....	7,614				
Turpentine, crude.....	191	Austr., U. K., Ar., U. S., Tunis.	Cement.....	33,197	G., R., U. S.
Feldspar.....	16,575		Copper sulphate.....	182	
Rennet.....	61		Ferrocyanides.....	69	
			Potassium chlorate.....	1,400	
Soap.....	59	G., Nor., Bra- zil. Finland, R., U. S.	Sodium: Chlorate of.....	483	R., G., U. K., N., Japan. N., G. Nor.
Lampblack.....	392		Sulphate of.....	598	
Red ocher.....	216		Sulphuric acid.....	203	
Tanning extracts.....	196		Superphosphate.....	17,245	
Matches (value, \$3,050,- 000).	26,868	India, U. K., Austr., U. S., Africa.	Tin and lead oxides.....	60	D., Nor., R., Austr.
Paper.....	137,510				

THE FUTURE FOR SWEDISH PRODUCTS.

From the foregoing table it is evident that, apart from the magnificent array of its wares based upon wood as a primary material, Sweden has already begun to export in quantity several other products of its chemical industry. The chief representatives in this class are cement and superphosphate, supplied chiefly to adjacent countries, and the chlorates and calcium carbide, products of the recently established electrochemical works. It is likely that the exportation of the latter products will steadily expand and that Sweden will become a strong competitor in the world's markets for electrochemical products on account of the cheap water power. That its paper and pulp exports will continue to increase is likewise probable. While for the moment the match trade shows no evidence of a check, there is less confidence in its future growth. Tariffs, fiscal regulations, and an increasing power and efficiency among foreign competitors are threatening to restrict the field of operations very seriously. For the time being the United Kingdom and the British Colonies are the best customers of the Swedish match trade.

EXPORTS TO THE UNITED STATES.

The values of the exports of chemical products to the United States in the four years 1907-1910 were as follows:

Articles.	1907	1908	1909	1910
Cement.....	\$41,000	\$7,000		
Chemicals (chiefly caustic alkalies).....	6,000	4,000	\$7,000	\$13,000
Fusel and tar oil.....		2,500		5,400
Glue.....		3,000		
Matches.....	112,000	124,000	207,000	157,000
Paper.....	276,000	496,000	850,000	623,000
Wood pulp:				
Chemical.....			1,318,000	1,636,000
Mechanical.....	499,000	1,060,000		4,500

The United States purchases Swedish bar iron to the amount of over \$1,000,000 annually, and about \$600,000 worth of wire rod, as well as smaller quantities of several other forms of the metal. The export of Swedish ferrosilicon to the United States was valued at \$5,000 in 1909, while in 1910 it had attained a value of \$51,000. Of much greater interest is the sudden increase of the American demand for Swedish iron ore. The value of the importations ranged from \$12,000 to \$32,000 during the period 1907-1909. In 1910 the figure reached \$983,000. For a number of years past America has purchased Swedish pig iron to an average annual value of \$90,000.

IMPORTANCE OF THE SWEDISH MARKET.

As the American manufacturers of heavy and finer chemicals approach the point of competing with Germany and Great Britain in the world's markets, they will find in the Swedish trade an important field. For the time being there is an opportunity to extend trade in colors, paints and pigments, blacking, varnishes, and a few similar articles, the value of which is already appreciated in Sweden. The consumption of quinine preparations is also relatively large.

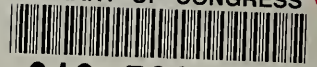
The outcome of the Swedish studies in the electric smelting of iron ores may mean much for certain iron deposits in the United States where conditions are not unlike those existing in Sweden.



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